DOCUMENT RESUME

ED 198 061 SO 013 143

AUTHOR Lakshmanan, T. R.: And Others
TITLE Urbanization and Environmental Quality. Resource Papers for College Geography.
INSTITUTION Association of American Geographers, Washington, D.C. Commission on College Geography.
SPONS AGENCY National Science Foundation, Washington, D.C.
REPORT NO AAG-RP-77-1: ISBN-0-89291-122-0
PUB DATE 77
NOTE 43p.
AVAILABLE FROM Association of American Geographers, National Office, 1710 16th Street, N.W., Washington, DC 20009 ($4.00).

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Developed Nations: Developing Nations; *Economic Development: Environmental Standards: Futures (of Society): Geography Instruction: Higher Education: *Policy Formation: Quality of Life: Resource Materials: *Urban Environment: *Urbanization: *Urban Problems

ABSTRACT

The resource paper examines urban problems related to the environment. It is suitable for use in undergraduate or graduate courses in urban geography, economic development and environment, urban environment, and environmental policy analysis. The paper is organized in five chapters. The introduction traces the concern with environmental quality which began in England and the United States around 1900. Chapter II provides perspectives on urban environmental quality. Topics include economic activities and environmental problems, and differentials in urban environmental quality. Chapter III discusses principles of urban environmental quality. Subjects are the physical impacts of urbanization: externality, social costs, pollution, and congestion: spatial structure of the urban environment: and input-output analysis of economic and envrionmental interactions. Chapters IV and V focus on the urban environment in affluent and low income societies. The Strategic Environmental Assessment System (SEAS) developed by the Environmental Protection Agency, the context of contemporary urbanization, resources for urban environmental improvement, and implications for environmental policy are discussed. Charts, maps, and tables depict problems and principles illustrated in each chapter. (KC)

URBANIZATION AND ENVIRONMENTAL QUALITY

T. R. Lakshmanan
Lata R. Chatterjee
The Johns Hopkins University

RESOURCE PAPERS FOR COLLEGE GEOGRAPHY
NO. 77-1

Consulting Services Publications
available from

Association of American Geographers
1710 Sixteenth St., N.W.
Washington, D.C. 20009

Geography as a Discipline, R. Huke, V. Malmstrom, 1973
Sources of Funds for College Geography Departments. S. J. Natoli, 1973
Planning College Geography Facilities: Guidelines for Space and Equipment (CCG General Series Publication No. 12), R. H. Stoddard, 1973
Community Internships for Undergraduate Geography Students, K. E. Corey, A. W. Stuart, 1973
Undergraduate Program Development in Geography. T. Burke, 1973
Geography in the Two-Year Colleges (CCG General Series Publication No. 10), Panel on Geography in the Two-Year Colleges, 1970

Library of Congress Card Number 76-57032
ISBN 0-89291 122-0

FOREWORD

In 1968, the Commission on College Geography of the Association of American Geographers published its first Resource Paper, *Theories of Urban Location*, by Brian J. L. Berry. In 1974, coinciding with the termination of NSF funding for the Commission, Resource Paper number 28 appeared, *The Underdevelopment and Modernization of the Third World*, by Anthony R. deSouza and Philip W. Porter. Of the many CCG activities, the Resource Papers Series became an effective means for permitting both teachers and students to keep abreast of developments in the field.

Because of the popularity and usefulness of the Resource Papers, the AAG applied for and received a two-year grant from NSF to continue to produce Resource Papers and to put the series on a self-supporting basis. The 1977 Series is the first group produced entirely with AAG funding.

In an effort to increase the utility of these papers, the Resource Papers Panel has attempted to be particularly sensitive to the currency of materials for undergraduate geography courses and to the writing style of these papers. The present Panel continues to affirm the original purposes of the Series, which are quoted below:

> The Resource Papers have been developed as expository documents for the use of both the student and the instructor. They are experimental in that they are designed to supplement existing texts and to fill a gap between significant research in American geography and readily accessible materials. The papers are concerned with important concepts or topics in modern geography and focus on one of three general themes: geographic theory; policy implications; or contemporary social relevance. They are designed to complement a variety of undergraduate college geography courses at the introductory and advanced level.

The Resource Papers are developed, printed, and distributed under the auspices of the Association of American Geographers. The ideas presented in these papers do not imply endorsement by the AAG.

Many individuals have assisted in producing these Resource Papers, and we wish to acknowledge those who assisted the Panel in reviewing the authors' prospectuses, in reading and commenting on the various drafts, and in making helpful suggestions. The Panel also acknowledges the perceptive suggestions and editorial assistance of Jane F. Castner of the AAG Central Office.

Salvatore J. Natoli
Educational Affairs Director
Association of American Geographers
Project Director and Editor, Resource Papers Series

Resource Papers Panel:

John F. Lounsbury, Arizona State University
Mark S. Monmonier, Syracuse University
Harold A. Winters, Michigan State University

SUGGESTIONS FOR CLASS USE

This Resource Paper on Urbanization and Environmental Quality can be used effectively as a basic textbook in undergraduate and possibly graduate courses in Urban Geography, Economic Development and Environment, Urban Environment, and Environmental Policy Analysis. The authors plan to use it in two of their courses, entitled Urbanization and Economic Development and Urbanization and Environmental Quality.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

7

I. INTRODUCTION

The current concern with the quality of the urban environment is, to a large extent, a confluence to two sources of public ferment. The first represents a concern with the protection of the quality of the natural environment that is threatened by the size and density of human activities in urban areas. Air pollution in urban areas is both an aesthetic insult and a health hazard. Polluted streams cause a loss of amenity by impairing recreational uses and by posing threats to human health and to other life forms. Solid wastes, the discards of production and consumption processes in street, field, and stream provide an added urban environmental burden.

The second concern focuses on the quality of the goods and services, such as housing, transportation, and public services, flowing out of the man-made or built urban environment. The way we have organized the provision of services, occupied urban space, and laid out public facilities greatly affects the amenity value of the urban living environment. Frequent complaints of the lengthy journey to work, the inaccessibility to outdoors, and the failure to preserve open space and aesthetic aspects of the cityscape suggest that urban areas fail to achieve either functional efficiency or aesthetic appeal. In an affluent, high consumption society, these defects of the urban environment may be among the most exasperating in their consequences on the quality of urban life.

The widespread concern with environmental quality thus stems from the changing nature of both the natural and built environments and their interrelationships. For instance, the cleanliness of a city's streets depends upon the rate of discard of solid wastes and the thoroughness and frequency of their removal. Solid waste discard is a matter of damage imposed by an individual's consumption on others in the urban area and is an issue of externalities. The collection and disposal of garbage is a matter of public service provision—the amount of sanitation funds budgeted and their effectiveness of application. The quality of sanitary services and environmental quality can thus be threatened from both sides: first, by increasing damages from activities that impose external costs, and second, by decreasing effectiveness of public sector activities devoted to improving urban environmental quality. To understand the quality of sanitation and its trends in a city one must consider both these elements. Urban environmental quality depends upon national urban factors.

In many ways, the public ferment surrounding the urban environment, expressed with all the passion and commitment of present-day commentators, is neither new nor novel. Many of the utopias and nightmares inherent in the contemporary controversy about the urban quality of life have their counterparts in the experience of the "urban transformation" in Victorian England or in the United States around 1900. In that period, the rapid process of urbanization, with its attendant congestion, pollution, and loss of amenity in the cities was such a profound experience that it occasioned impassioned controversy (Coleman, 1973).

We can do little more than guess what ordinary people of the time thought about their cities. But the idea of the city and the urban quality of life were subjects of considerable debate within higher culture—among literary and professional people, polemicists, and politicians. Nineteenth-century Britain, the first country to change from a rural society to a predominantly urban one, underwent a profound social transformation. The poverty, squalor, and terrible environmental conditions of the growing industrial cities turned many of the early literary figures (who originated from and identified with the countryside) into urban critics. Cowper, Wordsworth, and Dickens showed marked antipathy to cities.

> . . . cities then
> Attract us, and neglected nature pines
> Abandon'd, as unworthy of love
> But are not wholesome air . . .
> To be preferr'd to smoke, to the eclipse
> That metropolitan volcanoes make,
> Whose stygian throats breathe darkness all day long.
> (William Cowper, "God Made the Country," 1785)

Later writers such as Arnold, Kingsley, Carlyle, and Wells moved away from a simple Arcadianism and accepted cities and urbanization. Although sceptical of the social values of the new political economy of cities and critical of conditions of destitution and squalor, they nonetheless saw immense potentialities within urban society for improvement. The socialist writer, Friedrich Engels, found common ground with the urban critics in his *The Conditions of the Working Class in England in 1844*, condemning the tendencies and consequences of capitalist industrialization.

Although the critics were often in the majority, the city had its admirers among the liberals, such as David Ricardo and his fellow economists who were committed to economic competition, social individualism, and growth of national wealth. Between the critics and admirers, whose argument became one of quality and quantity, stood the public health reformers such as Edwin Chadwick and Joseph Chamberlain. Environmentalist in their approach to social problems, the latter argued that sewerage, drainage, and water supply would promote the material and moral well-being as well as the physical health of the urban poor.

As the pace of urbanization quickened toward the end of the century, the limitations of physical environmental improvement became clear, throwing into relief problems of housing, poverty, and nutritional standards and the prevailing ethic of laissez-faire. An apocalyptic note crept into the discussion and the suspicion was revived that cities were doomed. The economist John A. Hobson and the social critic William Booth both called for public intervention to tackle the ghetto, the decay of the urban core, and decentralization of cities through the development of transport networks. As the century ended, emerging suburbanization reduced urban population and housing densities, and local governments began to provide some services to help the poor directly and to improve the prospect of urban environmental quality.

In the United States, literature and philosophy have displayed a dominant trend of antiurbanism from Jefferson, through Emerson and Thoreau, to Louis Sullivan and Frank Lloyd Wright.[1] Although this trend reflected in part the effect of a romanticism that deprecated artificiality, science, and technology, it was largely a response to the horrors of the industrial city. Some of the critics of the city in the "Age of Reform," such as William James, Robert Park, Jane Addams, and John Dewey, urged not a return to nature but an empirical and rational attitude toward solving the problems of the city.

Although the attitudes of the intelligentsia in Britain and America to the urban experience differed, the quality of the urban environments they were responding to was not dissimilar. The growth of cities in the nineteenth century thus marked not only the beginning of the period in which aches and aspirations of modernity were felt but also the beginnings of the processes which have been seen since in global terms. Echoes of these nineteenth-century arguments exist in current controversies about urban decay and renewal, pollution, conservation, and crime, though the basic situation has changed.

Cities in affluent societies no longer alarm us by their number, size, and vitality or by their departure from an older social organization. In the more developed economies, the structure and character of cities have changed. Rising income and improved transportation and communications have permitted increased decentralization of population and economic activities from the dense urban cores. This deconcentration in the context of an improving distribution of income and the advent of a welfare state in the affluent societies have relieved the more depressing aspects of physical and social environmental degradation. Most of the poverty, disease, squalor, and human debasement that depressed observers of nineteenth- or early twentieth-century urban slums have disappeared. In fact, urban life, with its denser population, provides amenities that were not available in the "dull and brutish" life of the rural areas; and new skills picked up in the cities are often a more adequate basis for a richer life.

The cities in the developed economies still have social and physical environmental problems. Technology and urbanization that accompany rapid income growth in these societies lead to increasing urban pollution and congestion. *The increasing demand for goods and services is provided in a context where the societal incentives emphasize growth and consumption rather than quality of life.* Economic production and consumption techniques abound that do not charge the users of the media (air, water, land) or the facilities (roads, parks) the full costs that they impose on other urbanites. Consequently, air, water, and land pollution increase; and many of the common urban facilities and services that urbanites enjoy become congested. Problems of urban pollution and congestion have become generic problems of urban areas. Some of these problems are manageable in the cities of the developed countries, if cities can pay the necessary costs and devise the appropriate organization. These societies are beginning to establish standards of air and water quality, ration the portion of the capacity of the (built and natural) environment they want to use, and allow product price to reflect the cost of pollution or congestion.

An emerging class of environmental problems is growing out of new and complex technology in these societies, problems that are not amenable to mere pricing revision or other economic incentives. One example of such problems is the introduction into the environment of hazardous chemical pollutants believed to be carcinogenic or mutagenic. This class of environmental problems needs a variety of regulatory approaches—implementation of standards and prohibitions.

A mixture of these incentives and regulations can, when developed more fully, assure urban environmental quality if society can choose how much to pay and who gives up what to get how much environmental quality. In these affluent societies the necessary resources exist and many technical, economic, and administrative measures can improve environmental quality.

What may be needed for the long run is a strategic assessment of the consequences of growth in the economy, natural resource use, and environmental management policies on the future of the urban environment. Such a strategic assessment should help in anticipating and planning for future trouble spots in the environment—an approach quite different from the current reactive strategy to environmental problems after they have become serious and in some cases dangerous. We provide an illustration of such a strategic assessment approach in Chapter Four.

In the cities of the less developed countries, the environmental conditions are far more severe and their solutions merit a management approach different from the one outlined above. The increasing urbanization of the developing world is a natural stage in the process of economic development and one followed by the currently developed world. But the pace of urbanization, the low per capita incomes, and the inefficiencies in the provision of urban services combine to produce an appalling urban environment.

Gigantic urban agglomerations, such as Sao Paulo, Brazil, Calcutta, India, and Mexico City, Mexico,—some of which will soon be larger than the largest cities in the more developed countries—are now forming in these countries. Pollution and congestion are rampant.

[1] According to M. and L. White (1962), Walt Whitman and Henry James are exceptions.

Millions in these cities live in congested, unsanitary conditions. The low per capita incomes, in the context of demands for resources for other pressing needs such as industrialization and education, do not permit much investment for reducing urban congestion and pollution. What is even more alarming is that even the limited resources available for housing, water supply, or education are applied in a way that largely excludes the poor from access to these services. The quality of the greater part of the urban environment is even worse than the low resources of those countries would warrant.

Although the experience of the more advanced countries would undoubtedly help, the context of contemporary urbanization in the developing countries would warrant significantly different approaches. We would argue that urban environmental quality management in the developing countries would call for the development of physical and institutional technologies that are more consistent with their lower per capita income, underutilized labor, and limited management and institutional endowments.

II. PERSPECTIVES ON URBAN ENVIRONMENTAL QUALITY

Economic Activities and Environmental Problems

Pollution and congestion, as we observe them, result from increased use of resources accompanying economic growth. As modern agriculture, manufacturing, and mining activities expand, new metals and energy sources have been added as inputs to the economy—sometimes in such locations, times, and quantities as to constitute a threat to the environment.

The physical laws of conservation require that matter is neither destroyed nor created in the course of production or consumption so that there is always a balance between the mass of inputs to any process and the mass of outputs plus any mass created within the process (ignoring, of course, any transformed energy). This concept of a materials balance is applicable for both production and consumption processes.[2] Physical inputs (fuels, food, air, metals, etc.) are drawn from the environment and converted into energy and goods, generating in the process a variety of wastes. The consumption of these goods and services by households—driving a car, generating household garbage, or heating or cooling a home—leads to further generation of wastes.

Materials—food, fossil fuels—are drawn from the environment to generate energy and various food and industrial products. The production of these goods and their consumption by households lead to discharge of air, water, and land residuals and noise and waste heat into the environment. The environment has four major functions:

1) habitat for different life forms;
2) source of supply of materials (fuels, minerals, lumber, fish, water, and gases);
3) receptor and assimilator of wastes or residuals generated as a by-product of economic activity; and
4) source of amenities such as recreation areas or scenic views.

These four functions are crucial to the conduct of economic activities. Certain categories of economic activities are particularly significant in terms of the environmental burdens they generate. Four of these activities—energy use, production, household consumption, and urbanization—are viewed in Figure 1 as the key elements of the economy affecting environmental quality. The relationships between the first three of these economic activities and the environment have received considerable attention in the literature.[3] The rationale for introducing urbanization here lies in the special class of environmental problems that result from the concentration of energy use, production processes, and household consumption activities in urban space as described in the next section. Although rural areas have their own unique environmental problems, they are not the focus of this paper.

Figure 1 describes the broad relationships between the economy and the environment. The generation of energy from fossil fuels obtained from the environment produces the largest volume of active and troublesome residuals emitted in the U.S. Many factors influence a nation's total consumption of energy. Among these are its culture, industrial structure, climate, efficiency in energy use, and changes in income. The importance of income as a factor in energy consumption (and the consequent pollution) is shown in Figure 2. The level of energy use is directly relevant to the national per capita income, with some of the low income countries such as Guatemala below what their incomes would warrant. Among the affluent economies, the European nations and Japan consume less in general and the North American countries more than their incomes would suggest on an average. What is most interesting is the even

[2] This notion was developed in some detail by Ayres and Kneese (1969: 35-71).

[3] These are drawn from Freeman *et al.* (1973).

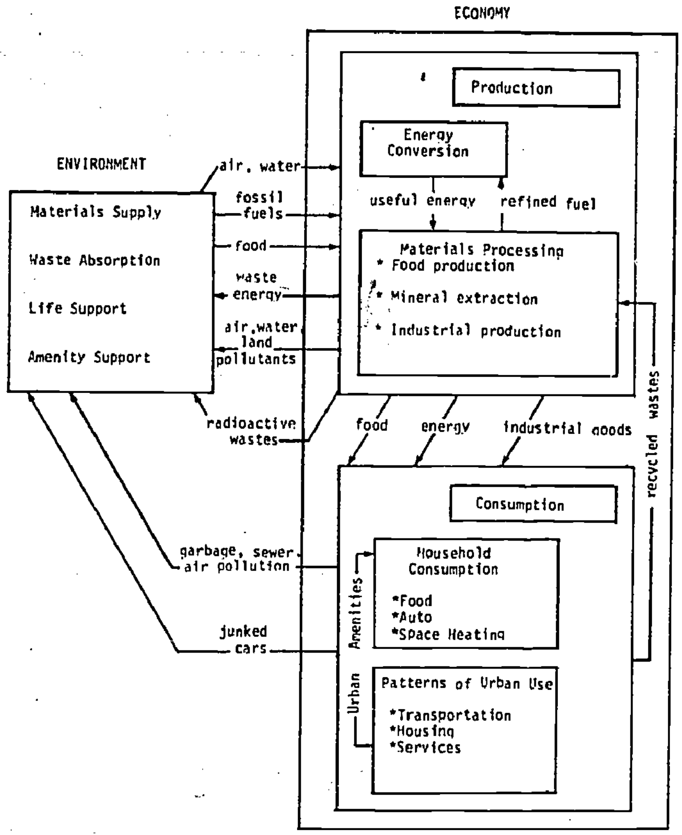


Figure 1. Economy and the Environment: the Interrelationships.

higher rate of energy consumption in the socialist economies of U.S.S.R. and East Germany.

The processing of materials in the production of food, fiber, various minerals including fuels, and the whole array of industrial goods is the second type of activity that generates residuals and burdens the environment. In an age of explosive technical advances, rapidly increasing income, and continued population growth, these two activities—energy conversion and materials processing—comprising the productive sector of the economy are major sources of wastes discharged into air, water, and land. Household consumption activities—space heating, transportation, and the consumption of many goods and services—are a third source of residual generation discharging solid and liquid wastes and air pollutants into the environment.

The fourth source of residual generation is the pattern of urbanization and urban space use. The way we organize the use of urban space—dense or sprawling, for example—greatly influences the amount of land converted to urban use, the transportation requirements, access to outdoors, and aesthetic aspects of urban living. Whether we have a compact or a sprawling city also affects the level of urban environmental pollution and the costs of pollution abatement as well as our ability to organize environmental management.

Figure 1 portrays the environment as a natural asset that performs valuable economic services. When the discharge of wastes by human activities exceeds the waste absorption capacity of the flora and fauna, the quality of these services or the environmental quality is adversely affected. Until the point that waste assimilation capacity of the environmental media is strained by the volume of wastes, there is no pollution problem. Pollution can be defined as the reduction in the environmental quality brought about by the discharge of residuals.

Although all four types of economic activities affect environmental quality, this resource paper focuses on one in particular—urbanization—and its effect on the quality of the environment.

Environmental Quality in and of Cities

The environmental problems associated with energy use, production, or household consumption affect the entire economy. They occur in both rural and urban areas. When they occur in urban areas, they may be termed environmental problems *in* urban areas. However, the environmental problems created by urbanization are peculiarly urban environmental problems. They are environmental problems *of* cities.

If these distinctly urban functions perform poorly—e.g., in creating poor housing, congested roads, and poor quality of service delivery—the quality of the urban environment deteriorates. We have then an environment problem *of* cities in addition to problems in cities—all the national environmental problems located in cities.

When society imposes regulations such as controlling emissions, switching to less polluting fuels, or pricing out pollution, environmental emissions resulting from production and household consumption will decline in

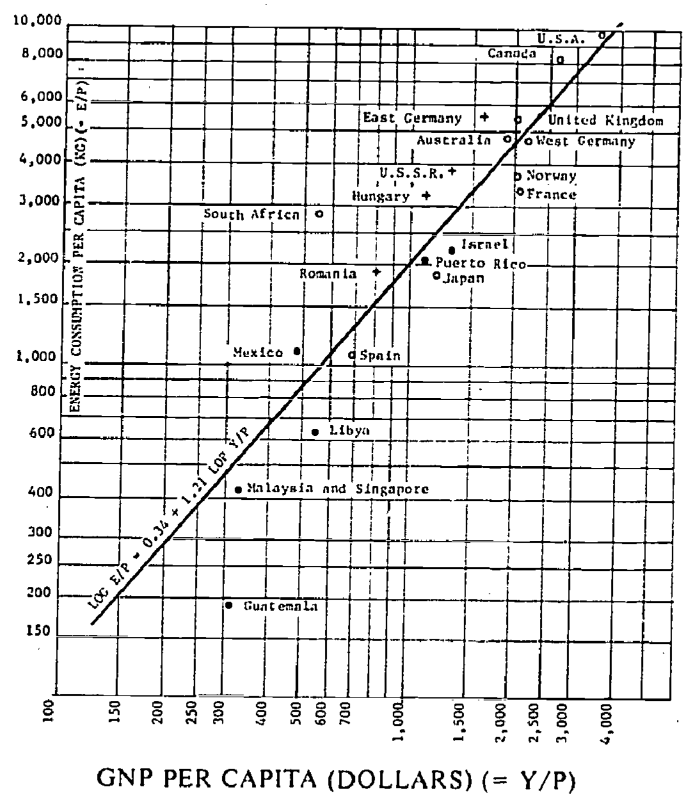


Figure 2. Energy Per Capita GNP in Selected Countries, 1965 (Adapted from Darmstadter, 1971: 66).

11

the nation and in cities. In other words, environmental pollution problems *in* cities will then decline. The environmental problems *of* cities will, on the other hand, depend upon how the cities organize and achieve quality in the built environment—i.e., in urban housing, transportation systems, and service delivery.

To summarize, the quality of the urban environment depends upon both national and urban processes and policies affecting the natural and built environment. If national legislative action postpones automobile emission control regulations, the air quality of cities will be adversely affected. Provisions in the U.S. Internal Revenue code or national housing mortgage policies and highway construction policies offer incentives for low density urban development and consequently affect the quality of the urban environment. In addition, patterns of land use, housing, and service delivery at the urban level affect urban environment. Urban and national policies and processes, therefore, jointly affect the environmental quality in and of cities. Policies to improve the quality of the urban environment have consequently both national and urban components. We will discuss the problems of the urban environment from this interrelated national-urban perspective.

To clarify the difference between problems of and in cities, it is useful to distinguish between activities in and activities of cities.[4] Whereas energy use, materials processing, or household consumption may be different in urban areas as opposed to nonurban areas, such activities are by no means urban. Production and consumption can take place anywhere. The activities of cities (those that are limited to cities), on the other hand, are geared to the central urban objective—the collection in space of people in order to achieve economies of scale in production, consumption, and social relationships. Addressing these objectives calls for additional activities that are distinctly urban. These urban activities are manifest in the pattern of occupancy of urban space and the structure of the built environment. These peculiarly urban functions are:

1) the selection of housing types or structural patterns in which the choices made by one urbanite are dependent on choices made by other urbanites;
2) the provision of transportation-communication pattern that facilitates efficient exchange between individuals and activities in urban space; and
3) the provision of services that are consumed in common or semiprivately (i.e., education, recreation, etc).

Differentials in Urban Environmental Quality

Urban environmental problems have arrived in various forms since the ancient Romans complained of the dumping of chamber pots, the clatter of chariots, and traffic congestion. Nineteenth-century British parliament did not meet some days because of the stench of sewage in the Thames. Teeming areas with bad sanitation in some large cities of contemporary developing countries are susceptible to epidemics.

[4] This distinction is analogous to that made by Leven (1968).

Table 1 shows illustrative types of environmental problems in contemporary urban areas of both affluent and poor societies. Some of these appear to pose threats to health, most others are merely nuisances or losses of amenity.

The environmental problems associated with the natural environment are of two types: discharge of pollutants into air, water, and land, and discharge of energy forms such as noise around airports or heat from power plants. Table 1 presents the nature of these pollutants, their sources, the types of damage they cause in urban areas as well as available information on the trends in the character and level of urban air or water pollution and their treatment options. Although these features of urban pollution will be discussed later in some detail, it may be interesting to note that in the U.S., for instance, there is evidence that urban air pollution has been declining recently (despite the increase in autos and production) because of fuel switching and pollution control devices installed in automobiles and factories. In the future, land use planning to reduce urban energy requirements may be additionally required to prevent an increase in the level of pollutants—yet another example of the interplay of national and urban policies that jointly determine urban environmental quality. Similarly, the level of noise pollution on residential properties near airports depends in the long run not only on the national technology of aircraft noise abatement but also urban land use planning that minimizes the development of incompatible land uses such as residences and schools around airports.

The problems associated with the built environment listed in Table 1 represent shortfalls in the quality of services urban residents receive. Crowding in parks or at beaches impairs the quality of recreational experience. Highway traffic jams and unsanitary slum housing are other examples of adverse quality of services urbanites share. Quality deterioration may be revealed in the time delays, psychic tension, or risk involved in a highway trip, and in the litter, noise, and crowding of swim or picnic space. As the next chapter will explain in some detail, the quality impairment results from a variety of societal incentives and policies that lead to the threshold or capacity of various facilities to be exceeded. The resulting deterioration of quality is an urban environmental problem.

Indicators of Urban Environmental Quality

What is the current status of the urban environmental quality? How does it vary among cities of different countries, among cities in one country, and among subareas within any one city? Is urban environmental quality getting better or worse? What trends are discernible in environmental quality in cities of different societies? A number of measures, indicators, and environmental indices have been developed in the last decade to describe the status and trends in the environment. The relevant literature is extensive and only the briefest reference is possible here.[5]

[5] See, for example, Council on Environmental Quality (1972: Chapter 1): Mitre Corporation (1972): Oak Ridge National Laboratory (1971): Ben-Chieh Liu (1975).

TABLE I. TYPES OF URBAN ENVIRONMENTAL PROBLEMS

Type of Problem	Pollutants and Source	Type of Service Quality Impairment	Nature of Damage
A. Natural Environment			
1. Air Pollution: SO_x, NO_x, CO, HC, Particulates	Oxides of sulfur, nitrogen and carbon (SO_x, NO_x, CO) and hydrocarbons (HC)		Danger to health in high concentrations; diseases; loss of amenity
2. Water Pollution	Sewage, plant materials, sediments, organic and inorganic chemicals, industrial and household activity		Hazards to health; impairment of recreational uses, aesthetic insults
3. Solid Wastes	Industry and household wastes; building rubble, hazardous industrial wastes		Fire and health hazards from organic garbage; aesthetic insults from auto junk yards and litter; disruption of wetland ecosystems; industry and household wastes; building rubble
4. Noise and Heat	Noise near highways and airports		Physical, psychic, and economic damage, e.g., hearing loss, sleep loss, loss of property value
B. Built Environment			
1. Residential Environment		Privacy, personal safety, level of sanitation	Health and productivity adversely affected; social pathology
2. Parks and Recreational Areas		Crowding; litter, noise from vehicles, etc.	Psychic disamenity
3. Transportation Systems		Traffic congestion; time delays; safety, limited modal choices	Loss of productive time; accidents, pollution, annoyance

An "indicator" is normally used to describe the condition of a single element or factor, which is part of a complex, interrelated system. Revealing indicators can be provided to describe the existing conditions of air pollution, quality of housing, and open space available. An example shown in Table 1 is a measure of sulfur oxide concentrations ($\mu g/m^3$). The quality of air depends not only on concentrations of sulfur oxides (SO_x) but on those of other air pollutants such as carbon monoxide (CO), nitric oxide (NO), particulates, and

TABLE 1. TYPES OF URBAN ENVIRONMENTAL PROBLEMS

Treatment	Measures of the Problem	Trends in Extent
Control of emission sources in factories, buildings, or vehicles; land use planning and relocation of activities	Concentrations of pollutants ($\mu g/m^3$); MAQI Index, EVI value	Recent decline in emissions because of auto exhaust and industrial source controls, fuel switching—small particulates increasingly a problem in cities of affluent countries
Secondary and tertiary treatment	Biological oxygen demand (BOD), PDI Index	
Collection and disposal in landfill, recycling	Pounds of solid waste per capita per day; percentage of generated waste that is collected in the urban areas; percentage of hazardous industrial wastes	Overall weight increasing; composition changing
Noise shield technology, land use planning	Decibels, Noise Exposure Index	
Eliminate substandard housing stock through upgrading, rehabilitation, and new construction; promoting "rational" consumption of environmental amenities	Persons per room, percent of population with sewer service and piped water	Housing environment improving in affluent countries—energy and resources intensive; in the poor countries, some evidence of increasing disparities between the poor and rich groups
Increase supply or control level and type of use	Participant visits/ time spent, etc.; size of available area for picnics or swimming	Increasing use of both private and public areas in affluent societies; tremendous congestion in poor countries
Increasing transportation facilities; changing the economic incentives to improve modal choice and traffic flow	Vehicle miles traveled; vehicles per lane and mix; average speed; accident rate	Increasing dominance of personal auto travel and relative and absolute decline of other modes

photochemical oxidants. Hence, a few indices that aggregate, weigh, and summarize the available data on a number of air and water pollutants—e.g., Mitre Air Quality Index (MAQI), Extreme Value Index (EVI) and Prevalence-Duration-Intensity Index (PDI)—have been proposed (Table 1).[6] However, these indices have not been field tested yet and are only partially satisfactory.

[6] See Mitre Corporation (1972). See also the excellent and elaborate treatment of these measures in Berry *et al.* (1974).

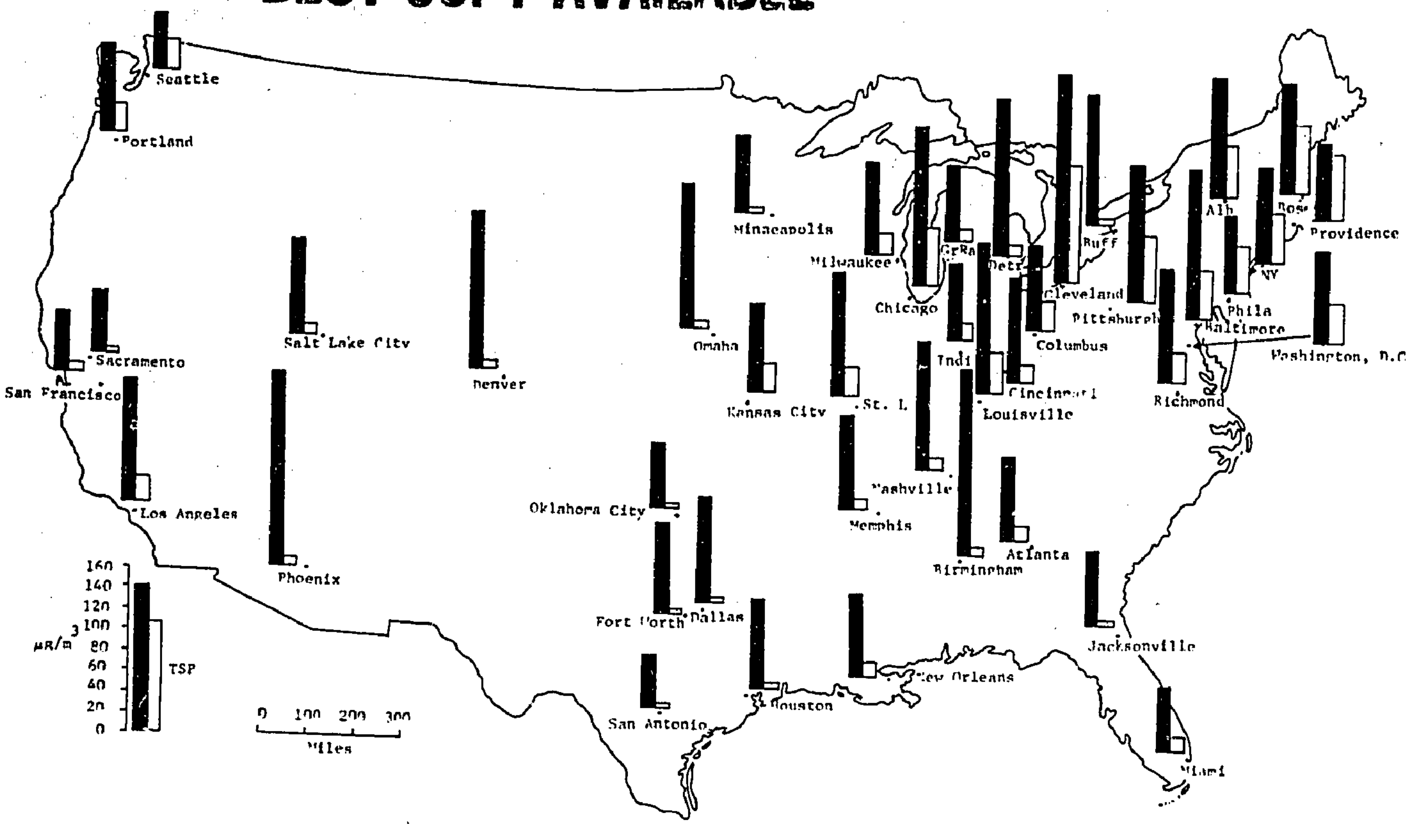


Figure 3. Mean Concentration of Sulfur Oxides and Total Suspended Particulates (TSP) in U.S. Cities, 1972 (Source: United States Environmental Protection Agency. 1972).

With this caveat in mind, the status and trends of urban environmental conditions are thus described in this paper by the more common indicators noted in Table 1.

Figure 3 shows the arithmetic mean level concentrations of sulfur oxides and the geometric mean concentrations of particulates in 1972 in the air over urban areas of the U.S. Higher levels of these two pollutants resulting from stationary source combustion for energy conversion and industrial processes are associated with, in general, the larger cities and cities with a higher concentration of more polluting sectors in industry (e.g. Cleveland, Ohio, Detroit, Michigan, Buffalo, New York).[7] Figure 4 shows the variations among the urban areas in the PDI index which allows a water body to be described in terms of the prevalence, duration, and intensity of its water pollution, corrected for natural background levels.[8] The higher the index, the worse the pollution. Lower water quality is associated with cities where heavy industries are significant (Pittsburgh, Pennsylvania, Chicago, Illinois, Indianapolis, Indiana). In general, the cities of the manufacturing belt—Boston, Massachusetts, Baltimore, Maryland, St. Louis, Missouri, Chicago region—have higher levels of air and water pollution than cities outside these sections.

Within urban areas, density is a factor in the distribution of most pollutants. For instance, the particulate concentrations generally decline from a maximum in central city to lows in the peripheral areas of the metropolis. This pattern is clear in Baltimore where the particulate concentrations decline from a maximum of over ninety $\mu gs/m^3$ in the central and eastern portions of the city where the swelling industries are located to less than fifty $\mu gs/m^3$ in the periphery (Figure 5). A similar pattern is also evident for sulfur oxide concentrations in an urban area of a developing country—Calcutta, India—where the polluting industries are concentrated on or near the Hooghly River (Figure 6).

Because air pollution declines in general from city center outward, the poor and blacks who are concentrated in the central city are exposed to higher pollution levels in most American cities (Figures 7 and 8).[9] In the U.S., about a quarter of the population is exposed to a total suspended particulate concentration above the national primary standards. In five cities—Birmingham, Alabama, Kansas City, Missouri, Macon, Georgia, Denver, Colorado, and Pittsburgh, Pennsylvania—this projection climbs to over fifty percent.

The disparity in air pollution experienced by the poor is great. The most pronounced is in the older industrial cities of the north central and northeastern U.S.—Gary, Indiana, Chicago, Illinois, Cleveland, Ohio, and Newark, New Jersey. The race-related disparities in exposure to air pollution are even more glaring than those associated with income. Thus the percentage of blacks in older industrial cities such as St. Louis, Gary, Newark, and Cleveland exposed to air pollution levels above the na-

[7] See the discussion of air pollution-city size relationships in Hoch (1972).

[8] See Mitre Corporation (1974: Table IV).

[9] See Patterson (1976).

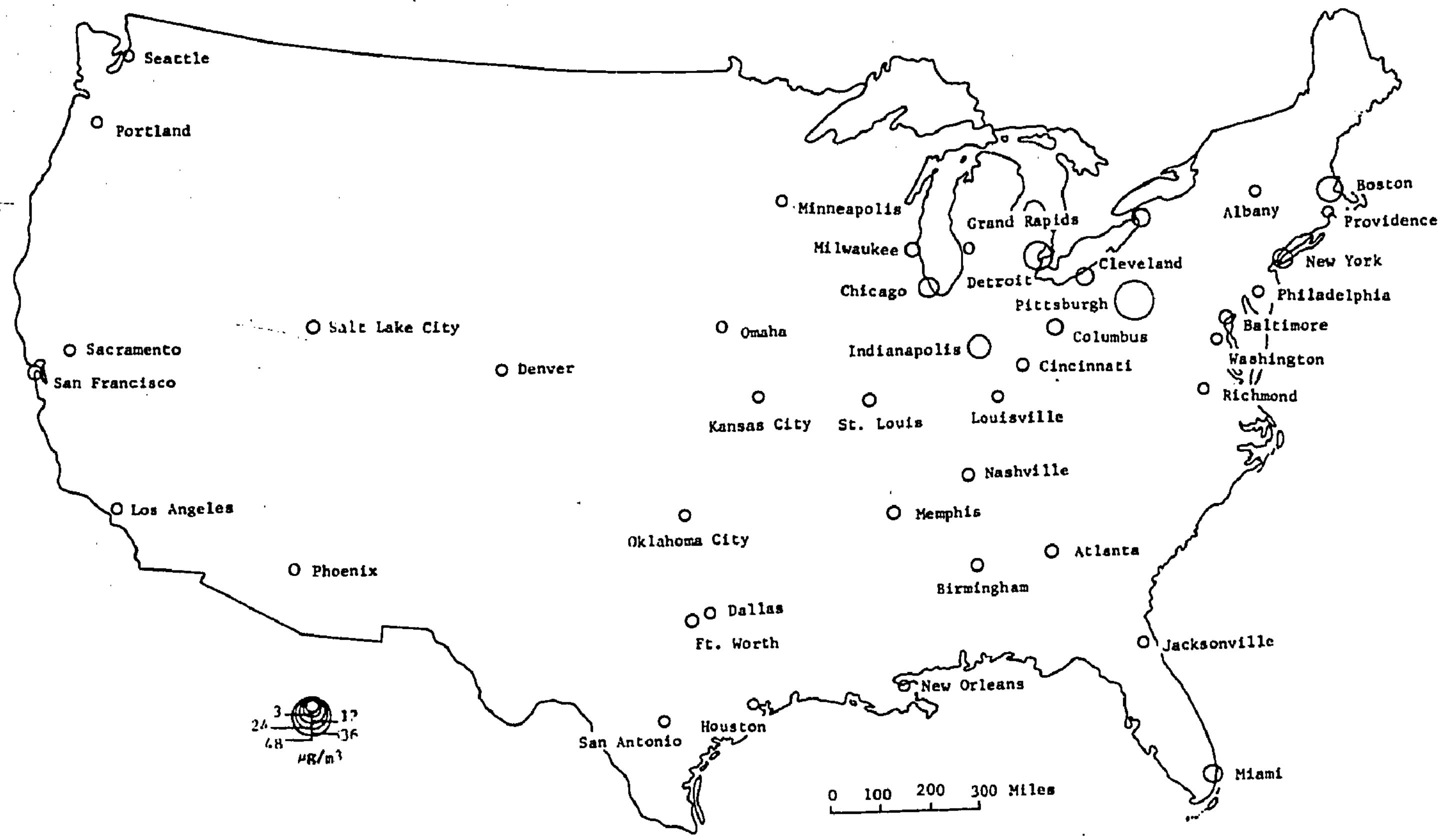


Figure 4. The Prevalence-Duration-Intensity (PDI) Index in U.S. Urban Areas, 1972 (Source: United States Environmental Protection Agency, 1972).

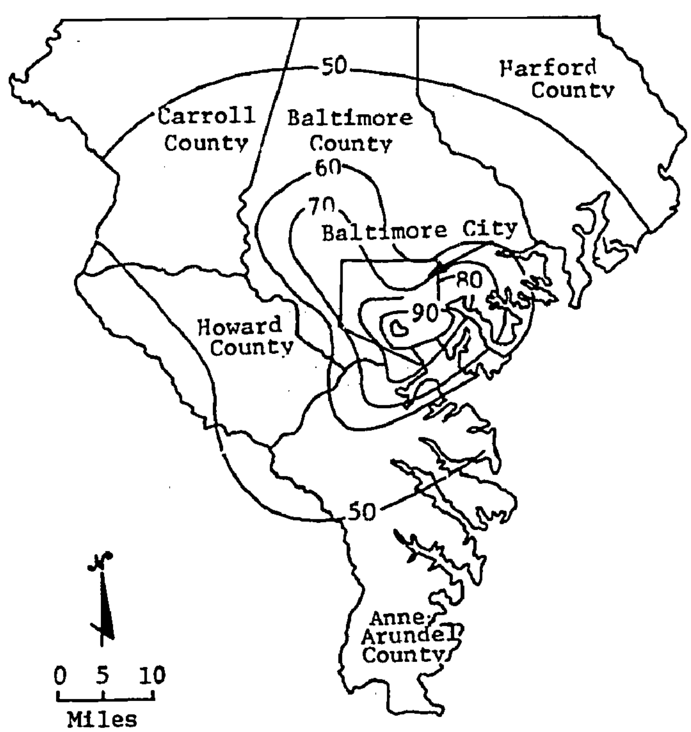


Figure 5. Observed Annual Average Particulate Concentration ($\mu g/m^3$), 1973 (Source: United States Environmental Protection Agency, 1974: 41).

tional primary standards in 1973 was twice as high as for whites (Figure 8).

Figure 9 presents the long-term trends in ambient levels of SO_2 and total suspended particulates in the U.S. In this period (1957-1970), characterized by major increases in population and industrialization, concentrations of some pollutants such as SO_x and TSP (Total Suspended Particulates) declined. There is some evi-

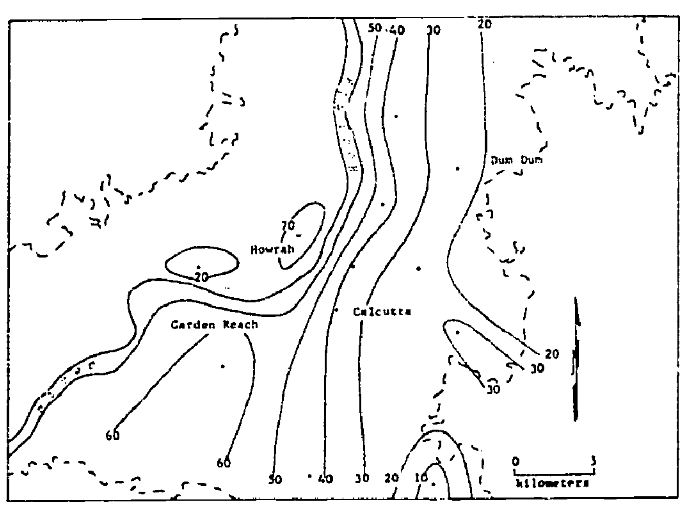


Figure 6. Average Observed Annual Sulfur Oxide Concentrations ($\mu g/m^3$) in Calcutta, 1972 (Data Source: Dave, 1975).

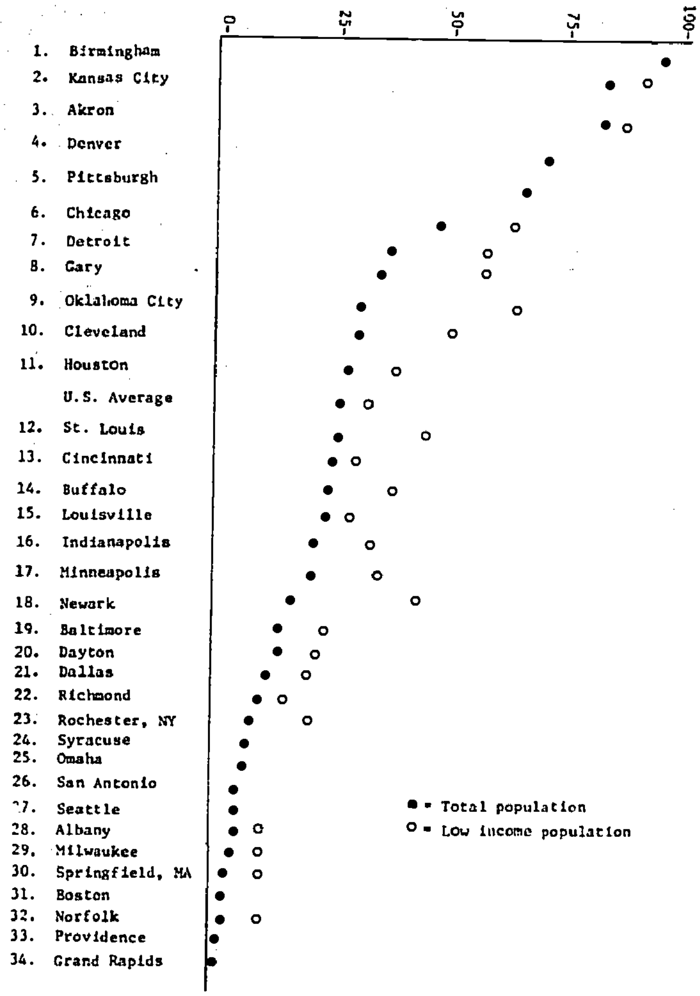


Figure 7. Percent of Total Population and Low Income Persons (Household Income Under $5,000) Exposed to Annual Average TSP Concentrations Above the National Primary Standards, 1973 (Source: Patterson, 1976: Figure 5).

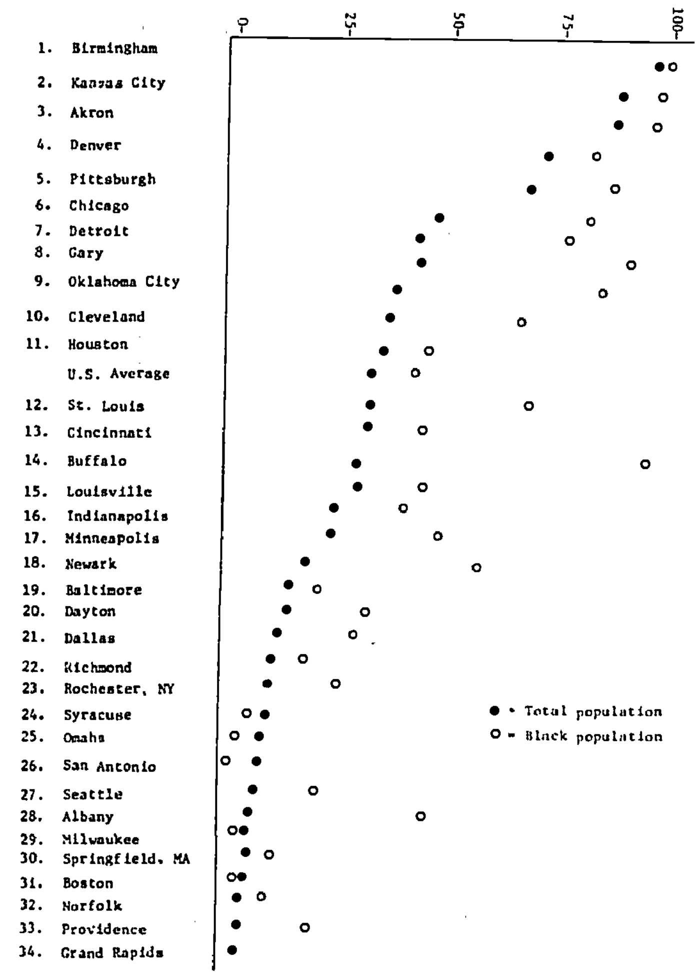


Figure 8. Percent of Total and Black Populations Exposed to Annual Average TSP Concentrations Above the National Primary Standards, 1973 (Source: Patterson, 1976).

dence that emissions of these pollutants have declined more rapidly in the seventies, whereas NO_x and ozone emissions continue to increase, with the result that the pollutant mix in the environment changes over time.

In the rapidly growing cities of the developing world, a key measure of urban environmental quality is the accessibility to piped-in water which reduces exposure to water-borne diseases. Figures 10 and 11 indicate the percentage of the urban population with access to water and sewer services in less developed countries (LDC's) in 1962 and 1970. In general, the greater the per capita income of a country, the more likely a higher proportion of its urbanites receive piped-in water or sewer service; thus a higher proportion of the population has these basic services in Latin American cities than in African or Asian cities. However, the rapid pace of urbanization in many Latin American countries appears to be swamping the effects of the significant increases in per capita income. The result is a decline in the proportion of urbanites having piped-in water service between 1962 and 1970. In any event, since the greater proportion of the urban population in the LDC's does not have the basic services, the urban environment in the LDC's is in large part unsanitary and hazardous to health.

Thus urban environmental inequalities exist in many forms: among residents within the same urban area (e.g., exposure to pollution, recreational amenities, access to services) as shown in Figures 7 and 8, and among resi-

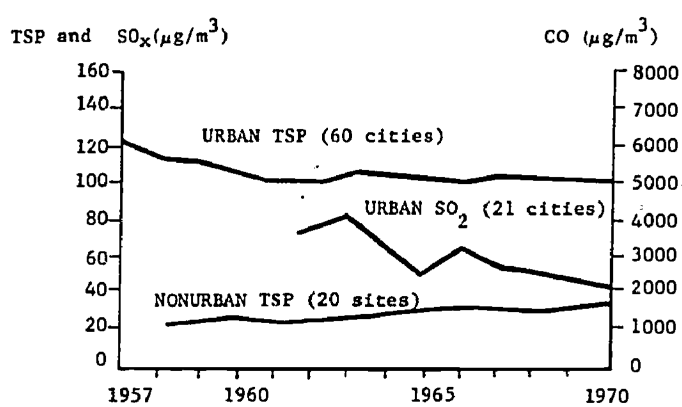


Figure 9. Trends in Ambient Levels of Selected Air Pollutants (Source: Council on Environmental Quality, 1972).

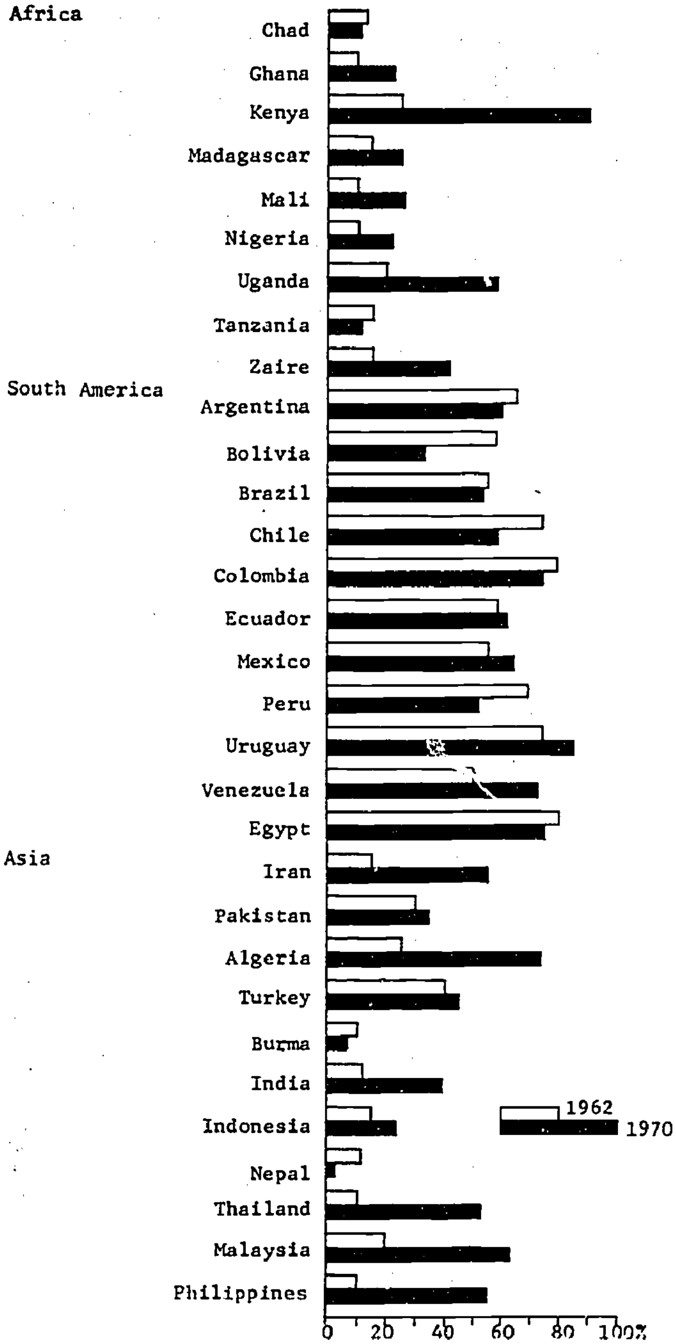


Figure 10. Urban Water Supply by House Connections (Source: World Health Organization, 1973).

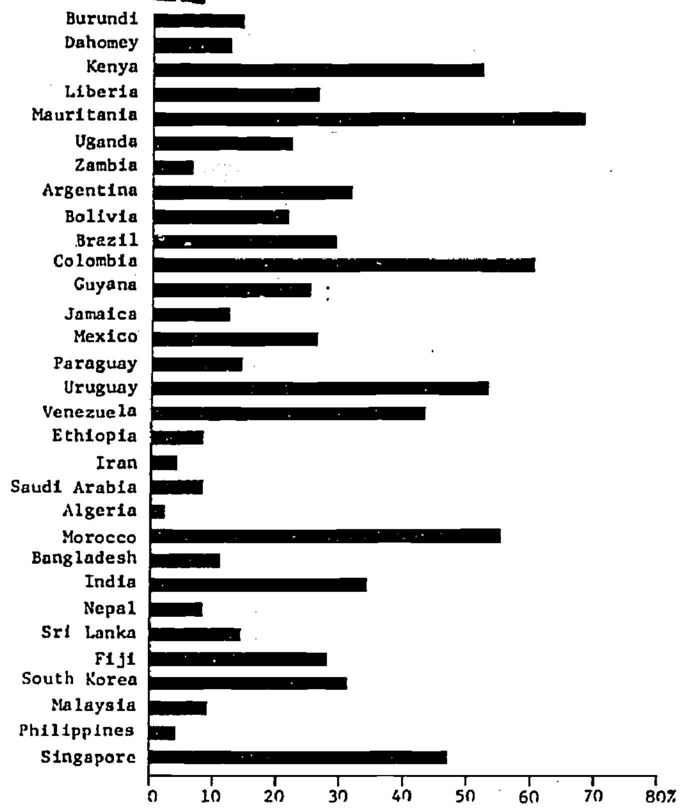


Figure 11. Population Connected to Public Sewage System, 1970 (Source: World Health Organization, 1973).

dents in cities of different countries, as shown in Figures 10 and 11. Such inequalities are universal and constitute a case for urban environmental policy.

What are appropriate strategies and policies for intervention? How does one choose from and combine various policy instruments, such as regulations, economic incentives, and spatial planning, to improve urban environmental quality? Our capacity to address these questions depends upon a sensitive understanding of the processes of urbanization and their effects on urban environment so that we can identify points and modes of intervention in these processes. Such an understanding is in its infancy, but enough work exists to define some principles of urban environmental quality. We will review these in the next chapter.

III. PRINCIPLES OF URBAN ENVIRONMENTAL QUALITY

This chapter attempts to survey both the established concepts and those now evolving to advance research in the field of urban environment. Because the analytical scope of the environment is broad and interdisciplinary, the relevant concepts span a broad range of social and physical sciences. We will not attempt to provide a comprehensive overview of thinking and research in this broad field. Rather, we have chosen selected concepts. These concepts are essentially a sampling—with a strong geographic-economic planning focus—of the theory and notions relating urbanization to the environmental quality in the context of public policy making.

The discussion is organized in two parts. The first part provides a view of the "state-of-the-art" pertaining to the physical effects of urban development—on climate, land, watersheds, and airsheds. Physical geographers have played a part in the theoretical and empirical development of this field.

The second part reviews a) the theoretical notions of spatial microeconomics of the urban environment and b) the macrospatial theory of the urban environment. We have drawn the relevant notions from analytical traditions in economic geography, environmental economics, and the regional scientist's bag of tools including input-output analysis and macroeconomic modeling.

It is this interdependence among economic, geographic, social, and physical notions that lends the study of urban environmental quality much of its fascination as well as its complexity. It also results in a wide range of styles adopted by authors in the field, from complex mathematical models to political polemics. The fusion of these diverse approaches into a coherent body of concepts relevant to urban environmental quality policy is an urgent task facing the ambitious researcher in the field. What follows is only a selective and individual probing of a vast and largely undefined field.

Physical Impacts of Urbanization

The impact of urbanization on the physical environment can be broadly classified into two categories, differentiated by the level, intensity, and quality of the impact. First, population and activity concentrations in urban areas transform some of the physical processes in the environment, such as the climate and hydrology (Detwyler and Marcus, 1972). However, any inferences regarding the determinantal consequences of these modifications are still speculative. Second, urbanization leads to increased pollution of various media—land, water, and air. Whereas research on climatic and hydrological modifications reflects the traditional interest of the physical geographer, interest in environmental pollution is a manifestation of new and developing concerns in the discipline as the scale and magnitude of urbanization processes pose potential and measurable threats to the biosphere.

In this section we will touch briefly on some aspects of the modification of the physical processes in the biosphere caused by urbanization on microclimate and hydrology, such as the heat island phenomenon, humidity, fog, precipitation, run-off, peak flow patterns, and flood characteristics.

Climate Modifications

Climate modifications resulting from urbanization can be classified by the scale and dimension of the area where modification occurs: (a) microscale processes (effects felt within fifteen km), (b) mesoscale processes (in the range of 15-200 km), and (c) macroscale processes or modifications of the global system.

The best evidence on climatic modifications resulting from urbanization is available at the microscale. In fact, the majority of microclimatic and hydrologic effects are measured at this level since they depend strongly on the local topographical and hydrological settings. In addition, these effects vary diurnally, weekly, and seasonally, and the degree of impact is often rather small. By contrast, there is considerable ambiguity regarding the effect of urban areas, which occupy such a small areal surface, at the macroscale or the global system. Mesoscale processes form an intermediate stage between the micro and global settings, and observations about the effects of urbanization on cloud systems, precipitation, and effects on hurricanes are available at this level. It is perhaps fair to say that inferences on the effects of urbanization are safest at the microscale and the hazard of generalization increases with scale.

Urbanization modifies the physical environment as it radically alters the natural surface by replacing a soil-plant surface with artificial, impervious, and reflecting surfaces of several types, and by the addition of a compact mass of buildings and roads. First, the increase in the impervious area tends to reduce the amount of infiltration and evapotranspiration. Surface detention storage characteristics are changed and street run-off collection arrangements and underground drainage conduits facilitate rapid removal of water from the surface. All these factors collectively change surface run-off regimes—a change that also alters groundwater recharge systems.

Second, reflecting surfaces and compact masses of buildings generate heat in addition to that generated in industrial and household activities. Emissions of particulates and gases (especially in developing countries that burn coal) alter the composition of the atmosphere. This influences not only incoming radiation, especially ultraviolet rays, but also reduces the net outgoing radiation.

Third, substantially altered precipitation run-off patterns combine with disturbed natural radiation balances to alter humidity, water vapor pressure, and precipitation. Built-up areas, especially high-rise buildings in central cities, provide obstacles to wind, alter the natural flow, and cause turbulence.

The urban microclimate is distinctly different in a built-up city as compared with its environs (Landsberg, 1970; Berry and Horton, 1974). Climatic change that has been most investigated is the heat island, an air temperature phenomenon. The tremendous growth of energy consumption in urbanized areas for space heating and transportation, combined with the altered heat transfer characteristics of built-up land, as noted earlier, have caused temperatures to be higher in the centers of all cities, regardless of size and topographic settings. The magnitude of this heat island is well correlated with population density and city growth rate, as Terjung (1974) illustrates. However, the relation between city size and degree of rural-urban temperature difference is not linear. Temperature contrasts are found even in small cities. Although general relationships have been developed between heat island magnitude and some parameters representing city size, the heat island magnitude at a given location depends also on local microclimatic conditions. In addition, the degree of warming varies diurnally, between days, weekly, and seasonally. It is greatest at night because of less soil cover in urban areas. It is lowest on Sundays, and there is also evidence of seasonal cycles.

Other atmospheric changes have also received attention. For example, water vapor balance is lower in urban areas than their environs as evaporation is lowered because of the impervious surface. Relative humidities are also lower and there is a tendency for urban areas to be drier

Increased amounts of condensation nuclei cause a higher frequency of fogs in cities than in their outlying areas. Fog incidence, dependent on the relative cleanliness of air, varies greatly among cities and among different decades in the same city. Cloudiness and precipitation increase because of increases in condensation nuclei, turbulence, and convection. Though considerable controversy still surrounds the issue on whether increased cloudiness causes increasing precipitation, studies show that several cities have higher rainfall than their environs.

For example, for the city of Bremen, Germany (on a fifteen-year average), precipitation was sixteen percent higher in the city as compared to its port at a distance of 1.5 km. In Moscow, between 1910 and 1962, precipitation was eleven percent higher than in its neighboring localities. In Paris, there is convincing evidence that the amount of precipitation on working days exceeds that on weekends (McPherson, 1974).

Hydrological Modifications

In spite of increased rainfall there is less moisture in urban areas than in their environs because of greater run-off coefficients. The most dramatic hydrological impact of urban development is on peak flows, where the basic lag time (or time of concentration) is reduced as an area becomes urbanized and the storm flow is concentrated in sharper, shorter, higher peaks than those of natural run-offs.

Greater run-off peaks occur as rates of permeability decrease. Flood peaks increase at a greater rate than the growth of the impervious areas depending upon natural vegetation and slopes. Undeveloped areas have a run-off coefficient of about 0.15 (fifteen percent of the precipitation runs off the surface). When development is dense, the run-off coefficient is .6. Thus, when there is heavy rainfall, the run-off per square km can increase from 1.5-2 m^3/sec. to 6-8 m^3/sec.—increasing the frequency and intensity of floods.

Table 2 provides estimates for typical urban development. Though the presence of extensive impervious surfaces is considered to be the foremost variable explaining the greater total volume of direct storm run-off in urban areas with comparable nonurban catchments, better means of collecting drainage at the surface and underground conduits for artificial drainage also alter storm run-off characteristics. The cumulative effects of increased rainfall, higher surface water volume, and improved underground drainage have accentuated localized peak flows and decreased base flows (McPherson, 1974). The increasing expansion of urban areas in the Schwippe Valley (Germany) over several decades has led to increasingly higher peak flows. Figures describing urbanization in the Schwippe Valley show the association between increasing urbanization and flood peaks (Figure 12).

TABLE 2. DEGREE OF IMPERVIOUSNESS ASSOCIATED WITH URBAN DEVELOPMENT PATTERNS

Land Use	Percent Imperviousness Low	Intermediate	High
Single Family Residential	12	25	40
Multiple Family Residential	60	70	80
Commercial	80	90	100
Industrial	40	70	90
Public and Quasi-Public	50	60	75

Source: Stankowski (1972).

Urbanization also causes morphological changes in the drainage system. Figure 13 indicates the diminution of tributary channels over a fifty-three-year period in the Rock Creek watershed in suburban Washington, D.C. Of the approximately sixty-five miles of natural flowing stream channel in 1913, only forty-two percent could be found in 1966. Consequently, much of the storm run-off has to be carried by storm sewers.

Another widely studied phenomenon is that of land subsidence resulting from intensive groundwater withdrawal for industrial and municipal use in large cities that are located on geologically young deposits, as, for example, in Japan. Probably the best known case of subsidence related to groundwater is that of Venice, Italy. Subsidence of ½m to 1m per year has also occurred in some Swedish cities.

Humans are capable of transforming their local environment in an almost endless variety of ways, over a matter of a few years in urban areas, because of density and intensity of use. Though the effects are still generally at the microlevel, we can expect to see more impacts at higher levels in the future. As urban areas expand continuously, the impact of urbanization may extend well beyond urban boundaries in the near future.

Spatial Microeconomics of the Urban Environment

The residents of an urban area consume jointly not only many of the natural, physical amenities offered by the physical environment but also a wide range of services provided largely through the public sector. The quality of urban life depends both on the level and quality of these public services and the quality of the physical media as affected by private activities of urban households and firms. As indicated earlier, the sanitary state of a city's streets depends upon both household disposal activities and the public provision of collection and disposal services. In a broader view, the quality of the urban environment depends on the attractiveness of its neighborhoods, safety in the streets, and the quality of its parks. The obvious point is that urban environ-

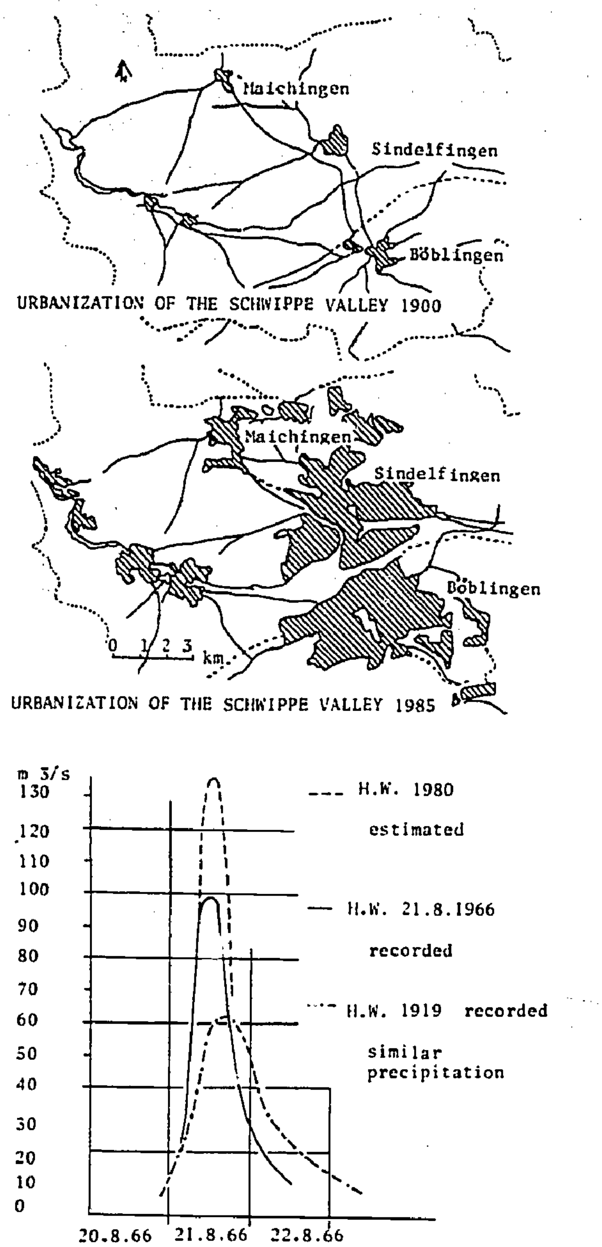


Figure 12. Urbanization and Flood Hydrographs in the Schwippe Valley (Source: After Bundesminister des Innern, 1971, in McPherson, 1974).

mental quality depends on how it is damaged as a side effect of private activities and on the nature of collective acts guided by the explicit purpose of enhancing the quality of life.

This section begins with a description of the theory of externalities as an explanation for the existence and pervasiveness of these damages imposed by private activities on the environment. This discussion also identifies the essential characteristics of urban pollution and congestion so as to treat both problems as members of the same class. The discussion proceeds to a brief identification of the formal character of providing public services that fundamentally affect urban environmental quality. Next, we will present the fusion of the theoretical notion of externalities and public sector into an intraurban spatial model of urban environmental quality proposed by Wingo (1973). Finally, we will use these theoretical notions to explore the analytical underpinning of various policy incentives that are commonly proposed to improve urban environmental quality.

Externality, Social Cost, Pollution, and Congestion

A fundamental principle of economic theory is that the free operation of perfectly competitive markets will lead to an efficient allocation of resources. For the efficient operation of the market in the public interest,[10] there must be perfect competition in all markets, complete information, complete mobility of factors, increasing costs in all industries, and the exclusion property. The last property refers to a characteristic which goods, services and factors of production must possess to allow the market system to function ideally. For a good, service, or factor to be "exclusive," anyone other than the buyer of the good must be excluded from the benefits it offers. A smallpox vaccine shot is a "good" not consistent with the exclusion principle. Although the person inoculated receives the benefit, the benefits are not exclusively that person's. Others in the community who do not pay for the individual's shot get the advantage of that person's immunity by decreased exposure to the disease. Such goods that are not subject to exclusion principle are said to have *spillover* effects. Those spillover effects (benefits or costs), when incident on third parties, are known as *externalities.*

In a modern and increasingly complex society, production and consumption processes lead to both spillover benefits (or external economies) and spillover costs (external diseconomies). If urban property owners landscape their properties, plant trees and flowers, and resod their lawns, the neighbors reap some of the benefits in the form of a pleasant view and increased property values for which they are not required to pay. They are the recipients of an external economy. Or consider the case of an industry that discharges wastes into air and water; downstream fishermen, swimmers, and municipal water systems thus have only restricted use of the river, incurring spillover costs or external diseconomies.

Since spillover costs and benefits pervade the urban economy, there are massive distortions in the allocation of society's resources. Either too much or too little will be produced of a good whose use generates spillover costs or benefits.

Figure 14A shows the case of external economies generated by an individual's demand (willingness to pay) for education. The reverse is shown in Figure 14B where spillover costs are imposed by the steel firm.

Pollution is thus the natural result of the operation of a production oriented system that treats air and water as free and unlimited goods. A free resource gets used more extensively than if a price were charged for its use. The most prevalent economic argument then is that pollution results from such imperfections in the application of property rights, and the imperfections can be corrected by specific policies such as pollution charges,

[10] Public interest is used in the sense that there is no arrangement of the society's resources which will produce an income greater than that generated by the market system.

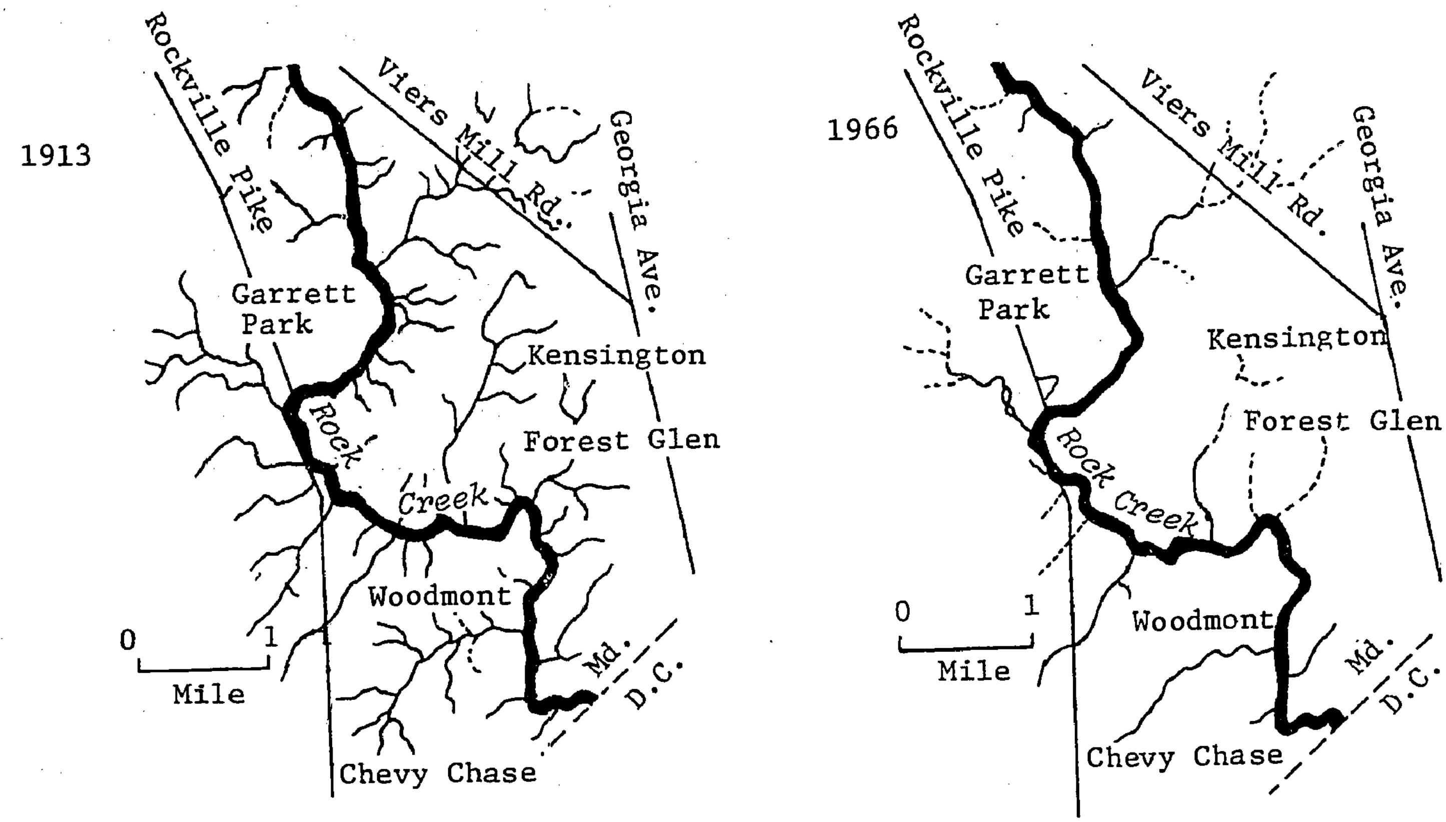


Figure 13. Reduction of Tributary Channels as a Result of Urbanization in Rock Creek Basin (Source: McPherson. 1974).

actions of the "right to pollute," or public controls.[11]

Rothenberg (1970:114) has suggested that the pollution problems described above belong in the same class as problems of urban congestion. Crowding of parks, beaches, or other public facilities, and highway traffic jams, are examples of urban congestion. Urban congestion is similar to pollution in being characterized by considerable externalities—both represent "the unkind rub of human activities on one another" with the relevant costs not reflected in the market. However, one characteristic distinguishes the externalities of congestion and pollution. In the case of congestion that is reciprocal, as for example, on a highway, users are damaging the quality of service both for themselves and for others. The essence of pollution, on the other hand, is that it is often nonreciprocal—there are some who pollute and others who experience the costs. Thus, pollution often lends itself to a distinction between constructive and destructive users and between victims and polluters.

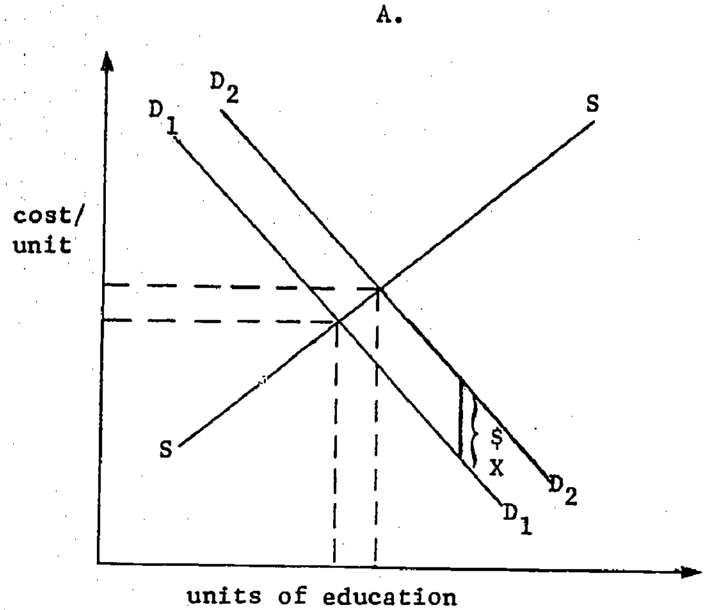
A more significant commonality between the two groups of phenomena is that crowded highways, urban noise, litter, packed picnic areas, or air pollution are all manifestations of social congestion. What are commonly termed pollution and congestion are a part of "generic congestion." The feature common to all of them is that many users are sharing a type of service. People are consuming or using a public good[12]—whether it be a water body, volume of air, highway, or park. The quality of service a person receives from the public good is adversely influenced by the presence of others. Decline in quality may be illustrated by time delays, reduced safety, and psychic tension of an auto trip or by litter, noise, and crowding at a park, or by eye irritation or odor in the air.

Each good—air medium, park, or water body—has a capacity or threshold, within which a wide variety of users can be accommodated with no shortfall in quality. For example, on an off-peak highway with traffic flow below the level of designed capacity, all drivers enjoy good service. When the traffic flow increases well past designed capacity, drivers experience congestion, time delays, and psychic tension. A crowded beach, or polluted air, water body, or land are other examples where the level of use of a socially shared medium exceeds its capacity and the quality of use suffers. In all these cases, when generic congestion takes place and congestion costs are imposed on others using the public good, there is a divergence between social and private costs of using a shared facility.

There are three policy options open to reduce the divergence between social and private costs in such cases. The first is the *pricing* strategy favored in eco-

[11] The reader may note that two alternative perspectives exist as to why the economy overproduces pollution. One of these, as illustrated by Kapp (1963) and Polyani (1957), holds that social costs are so pervasive that in a developed economy property rights cannot be adjusted to take all costs into consideration. A second position derives from Marxian notions that environmental problems and social costs stem from basic power relationships in society that underlie the system of property rights. so that the system itself is at fault.

[12] A pure public good is an extreme case of a good with spillover effects. No one can be excluded from benefits (e.g.. national defense).



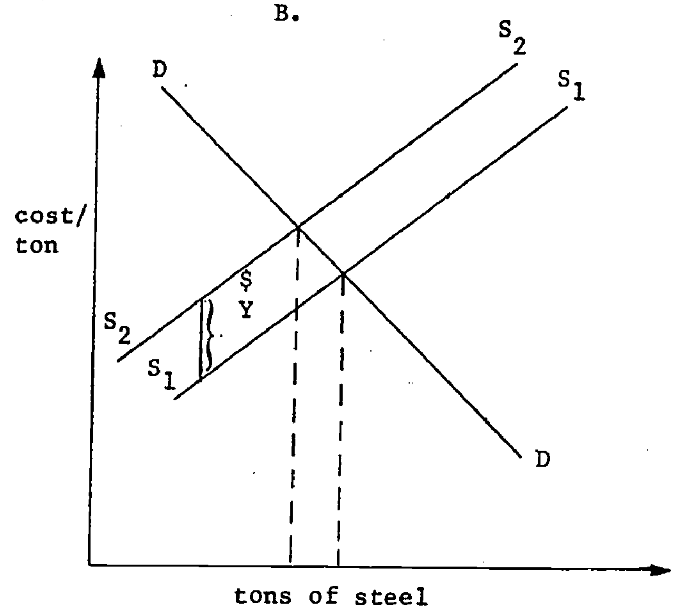


Figure 14. Spillover Benefits and Costs. In *Figure 14A*, D_1D_1 shows the potential buyers' willingness to pay for education at various prices. The costs of providing education are displayed by the supply curve SS—at higher prices, more units of education would be forthcoming. In a free market, Q_1 units of education would be produced and exchanged. But education of people involves spillover benefits for others since an educated citizenry provides society with economic growth opportunities and social stability which it would not otherwise have. If these spillover benefits ($ X) are added to the willingness to pay, the total demand for education will be given by D_2D_2. Only if output is carried to Q_2 are marginal costs equated to total marginal benefits. Consequently, the operation of the free market produces an output smaller than the socially optimum output of Q_2. In *Figure 14B*, although the supply curve S_1S_1 captures all the private costs of fabricating steel, the air and water pollution costs incident on the rest of society—reduced fish catch and higher concentrations of SO_x in the air—are not captured. If these spillover costs are added to private costs, the total social cost of fabricating steel is given by S_2S_2 to include spillover costs of $Y. From society's point of view, Q_1 is the optimum level of output, but the free market generates a higher output of Q_2 units. In the case of spillover costs, the free market output is greater than the optimum output that takes into account total social costs and gains.

nomic analysis. Because private decisions about using a medium such as air results in lower private costs than the social optimum, excess use of the medium takes place. It is argued that part of the demand must be choked off by rationing the use of the facility by a congestion toll equal to the difference between private and social costs. Each user pays the true cost of use, i.e., average private costs + congestion toll; thus facility use drops, restoring the quality of service. A number of examples of this strategy exist—pollution charges, road user fees and other congestion levies—to improve the quality of urban environmental service in different parts of the world.

The second policy approach is a *supply* strategy. This calls for investment in new capacity, i.e., widening highways, or building a subway, additional parks, or a municipal treatment plant. If enough additional capacity is added, there would be no congestion and the quality of facility service would be good.

The third approach is a *regulatory* strategy which calls for reducing the *demand* or the number of people using a facility. Prohibiting emissions of air or water pollutants, or limiting the use of a facility to preset levels are examples of this approach. Growth control ordinances provide an additional example. Local governments attempt to regulate the growth of their areas to deal with deterioration in urban environmental quality. Another example is to prohibit chemical pollutants that are serious health hazards (Greenberg, 1977).

In practice, it appears that a combination of these three approaches rather than a choice among them may be warranted. For instance, consider a familiar problem of the urban environment—rapid growth of automobile use and the attendant effects on congestion, pollution, and urban sprawl—in the cities of both affluent and poor societies. Table 3 addresses this problem by listing a variety of proposed measures that represent all three strategies mentioned above.

Examples of pricing policies that reduce auto travel in urban cores and promote public transportation are licensing of cars in central business districts during peak hours, charging high parking fees for autos, and providing subsidies to buses. It is reasonable to assume that the simultaneous use of all these instruments would achieve the objective of reducing auto use and increase the use of public transportation in the short run as Watson and Holland (1977) have described for Singapore.

The supply strategy measures augment traffic capacity—some by improved use of existing capacity, others by adding to it. The former class of measures, such as carpooling and exclusive bus lanes (as in the Washington, D.C. area), are less capital intensive than the investments in new capacity as a subway or personalized rapid transit systems. The latter measures that increase

TABLE 3. A CLASSIFICATION OF MEASURES TO IMPROVE URBAN TRAFFIC

Policy Strategy	Measures	Description of Measures	Time Frame
Pricing Strategy	(a) Area licensing	(a) Pricing the use of cars in downtown during peak hours	Short-Term
	(b) Subsidies and public transport	(b) Payments to bus companies to improve quality of service	Short-Term
	(c) Parking fees		Short-Term
Supply Strategy	(a) Increased efficiency of existing means of transportation	(a) Car pooling, exclusive bus lanes, etc.	Short-Term
	(b) New investment	(b) Build a rapid transit system	Medium-Term
	(c) Integrated transportation systems	(c) Planned integration of the various modes in the urban area	Medium-Term
Regulatory Strategy	(a) Timing measures	(a) Flexible working hours, staggered working hours, shift work, etc.	Medium-Term
	(b) Decentralization	(b) Measures to promote the evolution of mononucleated cities into multinucleated cities to affect the spatial and temporal structure of traffic	Long-Term

traffic capacity, such as investment, are more expensive and are useful over a longer period. In practice both classes of measures are implemented in a typical urban transportation plan.

The measures that reflect the regulatory strategy to manage traffic are of two kinds: measures that affect the *timing of facility use* and measures *that decentralize the urban activity centers.* The former measures, such as staggering the working hours for the labor force over a longer period in the day, tend to reduce the level of demand at peak hours. Since the highway investment depends upon the peak hour flow, this can reduce the demand for facilities. The idea behind the decentralization measure is that concentration of activities in the central business district (CBD) in a growing urban area forces heavy commuting in the morning into the CBD and out of it in the evening and promotes an inefficient use of the transportation facilities over time and in space. Any measures to promote other nuclei or activity centers in the urban area (while simultaneously improving the residential environment of the inner city) will distribute the traffic streams more evenly over the urban transport network. Further, promoting new activity centers in the context of peripheral expansion of the urban area whose populations and real per capita income are growing, will reduce the average travel distance and, therefore, the overall demand for travel (Hoover, 1968).

Spatial Structure of the Urban Environment

The *spatial* context is major ingredient of the quality of service provided by an urban environmental good or facility. The quality of service of a facility is determined, among other things, by how accessible it is to the user. If consumers have to cover a long distance to reach a park, a clinic, or any service facility, they will not only have to pay a high price for transportation and effort but also will require considerable investments of time. The money and time costs will act to restrict their potential consumption of those services. If reduced consumption leads to reduced satisfaction of demand, the environmental quality declines. For this reason analyses of the urban environment should be conducted in a spatial context.

Wingo (1973) provides a general analysis of the spatial structure of overall urban environmental quality. The Wingo model is a departure from the simplified partial analysis presented so far and instead focuses on the overall quality of the urban environment in any point in space. It is an attractive synthesis of notions of consumption theory and the geography of externalities into an illuminating description of the spatial structure of urban environmental quality.

Wingo points out that the quality of the environment at a point in space (within an urban neighborhood or a region inside a nation) is determined by:

1) the valued features of the natural environment present, i.e., amenity resources of the landscape, climate, etc.
2) the output of the public goods in that area, e.g., a variety of services provided in common, and
3) a set of unsolicited externalities that affect the resident in the geographic area.

By combining these three—natural amenities, output of public goods, and externalities—we can define the characteristics of each geographic area in space and these are the attributes of a spatial array of urban environments.

The natural amenities of a point in an urban area are defined by the endowment of physical amenities and the character of access to amenities elsewhere. The services or output of public goods at that point can also be defined in similar terms, as what services are accessible to that point. The externalities that accompany production and consumption are unsolicited by consumers at that point in space but nonetheless incident on them.[13]

These externalities that a resident experiences in any location in the urban area are not specific to but associated with the location. Some of the important externalities are of the following type:

1) Societal externalities: These are composed of benefits and costs that a resident in any area experiences through continuing contact with people who have characteristics the person values or rejects, e.g., the sensitivity shown by the American urbanite to neighbors of different ethnic or racial origin.
2) Externalities resulting from density or congestion in the neighborhood, some of which may lead to costs, increased irritability, etc.

The geography of natural amenities, the geography of public services, and the geography of externalities thus determine jointly the spatial organization of urban environmental quality. An urban area is thus a collection of various urban environments—each a unique creation of environmental goods. The consumption of these goods by urbanites requires access to these environments. Such access is possible by transportation, commuting, or migrating within the urban area. If the relevant environmental service is a park or a work place, transportation or commuting provides access. If, on the other hand, one desires access to a residential environment with its special collection of neighborhood services it is necessary to migrate or to relocate in that environment. Such a location confers the benefits of access to the desired bundle of amenities and public services accessible there; however, there are costs as well in that location in urban space. In the American metropolis, with its many political jurisdictions, these costs, represented by tax liabilities, vary over space. These tax liabilities reflect collective choices made in these jurisdictions regarding the level of provision of public services. The urbanite is confronted by a geography of residential environments and attendant tax liabilities. This choice of an environment can be described by the process of spatial choice that optimizes the best services-tax package available (Tiebout, 1956).

The spatial structure of urban environmental quality is thus influenced by a variety of processes, e.g., household location, internal migration, and social choice regarding public services. We do not yet understand many of these processes completely. As a matter of fact, Wingo's model represents a preliminary effort to develop an integrated framework for describing these various urban processes and their effects on environmental quality. Considerable work lies ahead.

Macrospatial Notions of the Urban Environment

Although much of the theoretical literature on the urban environment is represented by the microeconomic variety focusing on individual behavioral decisions, there is a growing body of macrotheoretical notions of the environment. Two strands of this literature are relevant to the environmental issues to be discussed in the next two chapters.

The first is the emerging literature on the variations in environmental quality among urban areas. The work in this field explores the relationships between the overall quality of the environment in a city and its attributes such as size, industrial mix, and regional location. This section provides only a brief review of the relationships between urban size and environmental quality.

The second stream of work pertains to the input-output analysis of economic-environmental relationships. Input-output analysis provides a framework for tracing the interdependencies between various producing and consuming sectors of an economy. As will be pointed out later, it provides a more complex view of the benefits and costs associated with an environmental problem than that provided by the partial analysis of Figure 14. Interregional versions of this model provide such information on interindustry and interregional effects.

Urban Scale and Environmental Quality

A major controversy in the economic and planning literature is the one surrounding the effects of city size on the quality of the urban environment. Because most observers hold that large urban areas have lower environmental quality, they can make a case for dismantling large cities or discouraging the growth of very large cities (Neutze, 1965). This view, postulating the dominance of external diseconomies in large cities, has been attacked for ignoring the external economies associated with large cities (Alonso, 1970; Hoch, 1972; Richardson, 1973). It is essential to clarify the analytical issues involved in this controversy since such proposals to limit city size are frequent, particularly in the developing countries where the cites are growing more rapidly than in the developed countries.

The case against large cities lies in the congestion, pollution, and other negative externalities associated with them. Table 4 seems to provide some empirical support for decreasing environmental quality with increases in size. But increasing size offers a variety of external economies of agglomeration, which accrue to:

1) Business firms as access to sources of capital, varied supplies of skilled labor, specialized business services, transport variety and cost savings, information and communication economies, economies in public services—all of these leading to greater innovation generation and diffusion potential.
2) Households as wider opportunities for the labor force, shopping, housing, and educational, health, and entertainment services—in short, consumption externalities.

These economies of agglomeration are evident in the higher value added per user and higher wages in the

[13] Externalities for the purpose at hand can be defined as those that are pervasive (not variable over space. e.g., national defense) and those that are spatially concentrated. The latter are those relevant to a definition of environmental quality of a subarea in the metropolis.

TABLE 4. METROPOLITAN SIZE AND INCIDENCE OF ENVIRONMENTAL PROBLEMS IN THE UNITED STATES

Metropolitan Population Size in 000	Fraction of Areas with Water Pollution Problems in 1965	Homicide Rates Per 100,000 Inhabitants	Air Pollution[1]			Solid Waste[1] Disposal Relative Costs Per Ton
			Particulates	SO_x	NO_x	
<100	0.381	<3.5	1.0	1.0	1.0	1.0
100-250	0.590	7.2				
250-500	0.625		1.4	2.3	1.3	1.6
500-1,000	0.714					
1,000-2,500	0.773	11.8				
>2,500	0.857		1.6	3.2	1.5	1.8

[1] Rough order of magnitudes estimated from Hoch (1972).

larger cities (Alonso, 1970; Hoch, 1972). The higher wages in the larger cities cover more than the increased cost of living associated with large size (primarily reflecting rent increases). The amount left over has been interpreted as compensation for the negative externalities and is great enough to attract and keep people in large cities (Hoch, 1972). Conversely, if negative externalities are less evident in smaller cities, their production and consumption external economies are also relatively restricted.

This argument about city size is, however, blurred in the large cities which are becoming multinucleated. These cities have grown by outward expansion into a low density periphery with a number of activity centers that provide a polynucleated structure. Persons living in the peripheral sections of large American metropolitan areas enjoy the benefits of low density environment in the countryside yet are near enough to the central portions of the large city to enjoy its external economies of production and consumption. From the point of view of advantages and disadvantages of large urban size, such individuals may in a way have their cake and eat it too (Alonso, 1970). The implication is that the issue of size may be less important than such issues as optimum urban density, the efficiency of spatial structure, or the opportunities for different styles of living both within and between cities (see Chapter Four).

Input-Output Analysis of Economic and Environmental Interactions

The partial equilibrium analysis of the economic effects (costs and benefits) of environmental pollution presented earlier in Figure 14B is an oversimplified view. Economy-wide effects and equity considerations, for instance, were not taken into account. Who are the losers and who are the gainers? The fishermen whose catches are reduced, the swimmers, and the oyster consumers are the losers. The gainers are the steel consumers who pay a lower price, the steel workers benefiting from the employment created by the higher output level, and owners of capital and land used in the production of steel. Thus it is not entirely evident that society as a whole loses or gains from not taking social costs into account.

The complexity of the economic-environmental relationships can be understood if one considers the full range of costs of providing and consuming a variety of products on other industries and in different regions.

A framework to describe and trace empirically the variety of interrelationships between industries is provided by the Leontief Input-Output (I-O) model (Miernyck, 1965). This model explicitly recognizes the interdependency between all producing and consuming sectors in an economy. The fundamental idea is that inputs to one industry are outputs of another and, in general, all industries are interrelated by providing each other's inputs and consuming each other's outputs. The industries also sell to "final demand" (composed of households, government, investment, and exports, all which drive the model). This model is useful in identifying interrelationships between industries and in tracing the dynamic implications of a change in one industry on others. Assume, for instance, that the insurance industry, which does not pollute the air, increases its output by fifty percent. Its purchases of the products of an air polluting industry such as paper will go up by fifty percent. As the paper industry expands its output to meet this demand, air pollution increases even though the insurance industry itself does not pollute the air.

If, on the other hand, the output of the paper industry is reduced by regulations controlling emissions, its sales and employment will drop. In addition, other industries that sell to the paper industry also will experience reductions in output and sales. Households will experience a drop in their income and consume less, and so on. Thus the direct effects of reduction of paper output and secondary or indirect effects on all other industries can be obtained from this model. The use of the input-output model makes possible the analysis of direct and indirect effects of environmental policies.

There are two extensions of this basic model that are relevant to environmental analysis. One is the interregional input-output model which permits analysis of the direct and indirect effects of specific environmental policies not only on all industries but in their respective regional locations (Miernyck, 1972; Richardson, 1973; Polenske, 1972). Thus if one uses an interregional I-O model available at the fifty-state level (in the U.S.), one can, for instance, trace the economic effects of increased output of coal in the western states or offshore oil development in the east coast on the economies and environment not only in the new energy producing states but also on other states in the U.S. Thus one effect of oil development off the coast of New England may be poorer air quality in New Jersey, whose refineries may use the crude oil produced off New England.

A second extension of the I-O model is to include the environment in the model. This is done by viewing the environment as an additional sector in the I-O model and by using data from the base year to estimate the environmental inputs and outputs per unit of industrial output. This permits the estimation of the impact on the environment of industrial activity that is necessary to produce a specified pattern of final demand. Alternative formulations of economic environmental models are becoming available. Some of these link the material flows between the economy and the environment and have undergone empirical development (Leontief *et al.*, 1975; Lakshmanan, 1975; Patterson and Ratick, 1975; House 1977). The next two chapters will describe these in terms of their structure and utility for environmental and urban policy analysis.

IV. URBAN ENVIRONMENT IN AFFLUENT SOCIETIES

Urbanization is a process of structural transformation that has accompanied modern economic development (Kuznets, 1973). In the industrialized, affluent countries, the trend to the city is most advanced, with the greater portion of the population in the urban areas (see Table 7 in Chapter Five). The quality of the urban environment in such societies largely determines the quality of life for most of the population.

These urbanized areas, which are almost exclusively built environments, experience a variety of congestion and pollution problems. The breadth, scope, and complexity of these problems has been broadly outlined in the previous sections. They range from pollution of the air, water, or land to congestion on highways and in parks, to poor quality of many urban services. These problems experienced by all urbanites pose a serious threat to amenity and, to some degree, to health. In terms of cost and attention required, they probably dwarf most other aspects of the national environmental problems.

In affluent societies, there is a pronounced demand for relief from these problems as witnessed by the power of the environmental movement in the U.S. and elsewhere in the North Atlantic community. Their large scale investments in highways, parks, sewer systems, incineration plants, and other facilities are expressions to improve the quality of the urban environment. In any one year, these countries invest considerable resources to develop the built environment. Currently in the United Kingdom, for instance, this amounts to about eight to nine percent of the Gross National Product or about fifty percent of total annual capital formation. When we add the costs of maintenance and improvement, the resources used represent about twelve to thirteen percent of the GNP. It has been estimated that in the last four decades of this century, the United Kingdom may spend 500 billion dollars to develop, renew, and maintain the built environment (Stone, 1973). This level of commitment to the built environment and to urban environmental quality is typical of other affluent societies.

Affluent societies possess and invest considerable resources in reducing the damage to health and amenity posed by urban pollution and congestion.[14] As indicated in Chapter Three, these resources should be deployed in a context in which free access to common property resources is not allowed. Standards of air and water quality can be established, environmental assimilative capacity can be rationed, and the price of products can be increased to reflect the cost of environmental protection. Such approaches involve augmenting capacity (of an airshed, watershed, or highway) and scheduling of use, and call for systematic management techniques.

Although we can deal with a number of environmental problems by *fine tuning* the market system—revising economic incentives and regulations or increasing the supply of facilities—there are limits to this fine tuning.

A key additional dimension is the spatial organization of cities. For instance, the way we organize the use of space has profound implications for almost every facet of urban life. In particular, it greatly influences the amount of land required for urban use, the transportation requirements and choices of modes, access to outdoors, possibilities for preservation of natural areas, and the overall convenience and efficiency of the urban system. It also affects the level of energy use in the residential and transportation sectors and the amount of environmental pollution. Thus it is widely conceded that the broad environmental quality implications of an urban area that has a compact spatial structure are different from those of a low density, sprawling urban area (Berry *et al.*, 1974; RERC, 1974; Keyes, 1976). Such spatial differences in environmental quality resulting from macropatterns of land use are a legitimate theme of geographic inquiry and public policy. This chapter pro-

[14] Research estimates of some of the damages to health are significant. Although controversies about methods and data surround such estimates, they may be useful as indicators. An early statistical study of cities found that higher levels of sulfate and particulate pollution are associated with mortality from cancer and heart disease. The estimate is that a fifty percent decrease in air pollution may increase life expectancy by three to five years (Lave and Seskin, 1970).

vides a brief survey of the available evidence on the issue of environmental quality and urban spatial organization, a generic issue in all affluent societies.

In any economically advanced and technologically sophisticated country, the indirect or secondary effects of urbanization on the environment are so diverse and widespread that they are indistinguishable from the general effects of technology and affluence. There is, therefore, a need for a long view of the economy, urbanization, environment, and resources. Such a future-oriented, long-term view can trace the relationships among growth in population, real per capita income, environmental burdens, urban quality, and natural resource depletion. This analysis can reveal the constraints that environmental quality and natural resource supply imply for continuing a high consumption, high amenity society, the possible avenues for release from such constraints, and the social values and attitudes necessary for addressing long-term environmental and resource problems. These themes—future potentials, problems, constraints, and choices—form the elements of a *strategic* view of the future economy and the environment.

A strategic view of the economy, resources, and the environment of a country can identify the resource and environmental consequences implied in economic growth and help in the formulation of long-term and short-term policies required to assure the maintenance of a high amenity society without adverse effects on the environment. An ongoing assessment of the environment in the U.S. is the third theme of this chapter, illustrating the potentials and problems of such a research endeavor. This research and policy analysis activity, dubbed the Strategic Environmental Assessment System (SEAS) model, is described next.

Strategic Environmental Assessment System (SEAS)

An avalanche of recent writing has drawn attention to the alarmingly increasing burden on the environment and natural resources generated by the growth in population and per capita consumption. Two strands are evident in this literature. One is conceptual—structuring the theoretical approaches to the study of environmental policy. An excellent example is the seminal work of Kenneth Boulding, who views the earth as a closed system for inputs and outputs of economic activity. The objective must be maintaining the stock or condition or state of the people rather than maximizing the throughput of goods. Boulding (1970) points out that

> economic activity is a throughput, a linear process from the mine to the garbage dump. . . . [The real measure of economic welfare] is the state or condition of a person or of society. . . . Consumption is decay—your automobile wearing out, your clothes becoming threadbare. It is burning up gasoline. . . . Consumption is a bad, not a good thing; production is what we must undergo because of consumption.[15]

The second strand is represented by the neo-Malthusian gloom presented in *The Limits to Growth* (Meadows *et al.*, 1972). This work suggests that the world economy is likely to collapse if exponential growth continues. It revives the old devils of classical (Malthusian) economics—population expansion and resource depletion—and throws in, for good measure, the new devil of increasing environmental pollution. It has been suggested that the assumptions of the model assure that gloom is input to the model and the results are not surprising (Carter, 1973). Although the assumptions and the alarmist tone of the Meadows work may have undermined its usefulness, there is a real need for a strategic assessment of the future environment and it must be addressed at the national and international levels. Currently several countries are making attempts to develop models to monitor their environments. We will describe one such model for illustrative purposes.

The SEAS model represents an effort by the U.S. Environmental Protection Agency (EPA) to develop such a strategic assessment of the U.S. economy, environment, and natural resources. SEAS has been developed by EPA to help assess the impacts of environmental issues and policies on national economic development and environmental quality and to improve our understanding of the effects of alternative development paths and policies in the U.S. Such an improved understanding may throw light on certain conflicts that might exist among the goals of improving economic welfare, improving the quality of the environment (including the urban built environment), and assuring an adequate supply of natural resources. Although the scope and implementation of the constellations of the economic-environmental models (or modules) that comprise the SEAS model system are beyond the scope of this paper, we will present a brief outline of the model to highlight its strategic assessment capabilities and its urban components (Lakshmanan and Krishnamoorti, 1973; House, 1977; Patterson and Ratick, 1975).

Table 5 provides brief descriptions of the major components of the model system and linkage between the various modules. Three modules describe the national economic system. The core module is INFORUM—a 185-sector national input-output model organized and maintained as a forecasting system developing projections of a detailed structure of economic activity annually for fifteen years (currently to year 2000). Other modules of SEAS disaggregate these economic sectors and estimate the air, water, and lead pollutant emissions, energy use, and natural resource consumption, consistent with the level of economic activities in INFORUM. The major pollutant-producing sectors of the INFORUM are disaggregated in INSIDE. Since there is often considerable variation in residual generation among different processes even in the same sector, INSIDE disaggregates these 185 sectors with 351 process subsectors. ABATE generates costs associated with meeting environmental standards. These abatement costs are fed back into INFORUM so as to modify the capital accounts in the I-O matrix.

Two modules, ENERGY and STOCKS, describe the natural resource component. RESGEN, the national residuals generation module, computes national estimates of water and air residuals associated with the

[15] The idea of spaceship earth and emphasis on stock rather than consumption appeared earlier, in Boulding (1966).

TABLE 5. THE SEAS MODEL SYSTEM

Module	Description	Outputs	Relation to Other Modules
A. Economic			
1. INFORUM	An expanded version of the University of Maryland 185 sector I-O model of the U.S. economy (Almon, 1974). An elaborate system of forecasting components of final demand which set in motion annual forecasts of industrial output by these sectors for fifteen years (currently to year 2000).	A summary of GNP projections annually to year 2000 in billions of 1971 dollars; sector breakdown of personal consumption expenditures investment, output, exports, employment, and productivity in billions of 1971 dollars.	The core module defining the level of economic activity that influences the level of residuals, abatement costs, energy use, and natural resource use. The effects of price changes resulting from abatement expenditures are fed back into INFORUM to affect future economic structure.
2. INSIDE	Disaggregates major pollutant-producing sectors in INFORUM through side equations—in cases where a single INFORUM sector includes subsectors or processes that generate residuals at levels significantly different from other subsectors and processes inside that INFORUM sector.	Output and residuals by each of 351 subsectors.	Linked directly to INFORUM.
3. ABATE	Generates costs associated with meeting environmental standards for output levels predicted by INFORUM for water pollution, air pollution (excluding control of automatic pollution), and radiation wastes. The operating and capital costs of abatement are incorporated as feedbacks into INFORUM so that I-O matrix and capital accounts are modified appropriately.	Abatement costs by medium (air, water, etc.) of abatement, and by sector annually; municipal charges for water abating industries.	Feedback to INFORUM to reflect purchases of energy, chemicals, etc. and capital investment goods.
B. Natural Resources			
4. ENERGY	Estimates the level of energy demand in the industrial, residential, commercial, and transportation sectors consistent with the level of output, resource requirements by fuel type and investment requirements corresponding to this energy demand.	Energy flows by type and industry in BTU's; investment by year.	Linked to INFORUM and the various RESIDUALS models.
5. STOCKS	Estimates the effects of economic growth on raw material depletion. Both domestic production and importation of raw materials are figured into the stocks output, as are the effects of recycling.	For selected years, quality of resources demanded, and imported; price of resource and inventory at year end.	Linked to INFORUM and RESIDUALS models.
C. Residuals			
6. RESGEN	National estimates of water and air residuals associated with each of the economic activities in INFORUM and INSIDE.	Gross and net annual tonnages by industry into various media.	INFORUM and INSIDE.
7. SOLRECYC	Provides solid waste discharges with separate accounting for materials recycled.	Tonnages.	INFORUM and INSIDE.
8. LANDUSE	Describes water pollution from nonpoint sources (agricultural and urban areas).		
9. TRANS	Describes emission and abatement costs associated with transportation by different modes (automobiles, buses, rapid transit, railroads, and aircraft).	Developed the emission tonnages, abatement costs at the state and SMSA levels.	
10. REGION	Disaggregates by state, SMSA, or river basins the national forecasts of economic activity and pollution made in INFORUM, INSIDE, and RESGEN.	Output and emissions by sector, by geographic area.	
11. AIRAMB and WATERQUAL	Projects concentration levels of major air and water pollutants.	For the 247 Air Quality Control Regions (AQCR's) and subareas; ambient concentrations (CO, SO_x, NO_x, particulates) relative to national standards are presented.	Linked to REGION, TRANS and RESGEN.

economic activities described in INFORUM and INSIDE—over 400 pollutant-producing economic sectors and subsectors. RESGEN permits a reasonable accounting of the residuals produced in a specified year at both the national and regional levels with the output being sensitive to changes in the mix and level of economic activity.

Still others disaggregate these national estimates of pollutants to the state and metropolitan level and model, in addition, the residuals generated by transportation and various land uses. The Air and Water Quality Indicator modules (AIRAMB and WATERQUAL) are intended to project levels of concentration of major pollutants in air and water at the level of 247 Air Quality Control Regions (AQCR's) and 99 aggregated subareas (ASA's). These experimental modules are still in the developmental stage, but because AQCR's are largely centered around urban areas, they are briefly described here.

Therefore, the SEAS is quite an elaborate model that brings together relationships and data pertaining to the economy, environment, and resources in a flexible framework that permits *conditional* estimates. Because of the general interdependence among all parts of the SEAS system, the level of each type of economic activity or environmental residual loadings or natural resource use (if not fixed by explicit assumption) will respond in some degree to changes introduced in any other part of the system.

This characteristic allows the flexible use of the SEAS model, permitting one to estimate the requirements for meeting specified levels of a wide variety of target variables. For instance, it is possible to estimate the emissions of various pollutants into air, water, and land, the level of energy use, and the critical natural resource consumption that are consistent with a given projection of growth of population and labor force. How would these implications vary for different rates of productivity or income change? What are the economic implications of different scenarios for resource supplies? What are the likely consequences on the automobile industry and related industries and on the urban environment if the U.S. delays adopting auto emission standards? What would be the economic energy and environmental consequences if the proportion of small cars in the American automobile fleet increased significantly in the next decade? How are urban areas of different size, income, and industrial mix likely to fare in the next decade or two under foreseeable economic changes and the implementation of environmental and energy regulations? The specific answers will, of course, depend on simultaneous assumptions made about such matters as population growth, labor force participation rate, federal government spending, environmental standards, resource supply policies of other countries, and the like, all of which can be introduced as alternative input scenarios in the model.

The rationale for describing the SEAS system in this paper on urban environment is to drive home one of our major themes: the problems of urban environmental quality in a highly integrated affluent society (such as the U.S. or any western European country) are partly extra-metropolitan—the result of the operation of the larger national economic system. Thus the level of pollution in the future in metropolises such as Pittsburgh, Pennsylvania, Denver, Colorado, Boston, Massachusetts, or Atlanta, Georgia is a function of a wide variety of extra-metropolitan factors—national birth rates, female labor participation rate, rate of growth of personal income, change in consumption or technology, national energy conservation policies, national environmental standards, or foreign natural resource supply policies. For instance, the level of SO_x ambient concentration in year 1985 or 1990 in urban areas will be influenced, among other things, by the likely future industrial mix and income growth and energy conservation or self-sufficiency policies such as emphasis on the use of coal in the nation. To understand urban environmental quality is to assess strategically the impacts of these broader events. A model of the SEAS variety is eminently suited for the assessment of such alternate future development scenarios.

Urban Form and Environmental Quality

We have noted earlier that the size and form of urban areas affect the quality of the environment. The review of the literature on urban size in Chapter Three suggested that there are economic advantages—higher incomes and diverse production and consumption opportunities—in urban size. But urban growth is often accompanied by deterioration of the physical and social environment. Historically, as large cities grew, a familiar method to escape deteriorating environmental amenities, such as pollution, noise, and congestion, was to occupy sequentially urban peripheral areas of lower density, thereby changing overall density and altering urban form.

Expansion of urban areas depended on improved transportation technology. In the last two decades or more, the widespread use of the automobile, increasing per capita incomes, and a variety of reinforcing public policies have accelerated the dispersion of both residences and jobs so that there is currently in affluent societies (most pronounced in the U.S. cities) a trend toward a dispersed city. The urban areas in the south and west of the U.S., which have grown in the last two decades contemporaneously with the automobile, have lower average densities and less centrality as compared with the older urban centers in the northeastern U.S. The adjustment to the automobile, by providing ample parking areas and by building urban freeways, has increased the accessibility of peripheral points to the urban center and, to a considerable degree, to each other. This has encouraged greater dispersion of both residences and jobs—a trend most pronounced in American cities but beginning to be evident in European cities as well (Hall, 1970). In Chicago, Illinois and Paris, France, for example, traffic per square mile is expected to show almost no increase in the central area between 1972 and 1980, with congestion likely to spread out rather than grow in intensity (OECD, 1973a).

Does the general trend in affluent societies towards the "spread city" reflect a preferred and efficient pat-

TABLE 6. PERCENTAGE CONTRIBUTION OF MOTOR VEHICLES TO TOTAL ATMOSPHERIC EMISSIONS IN TWELVE OECD[1] METROPOLITAN AREAS

City	Percentage of Total Emissions		
	CO	HC	NO_x
Madrid, Spain	95	90	35
Stockholm, Sweden	99	93	53
Tokyo, Japan	99	95	33
Osaka, Japan	99	95	25
Toronto, Canada	98	69	19
Chicago, U.S.	94	81	35
Los Angeles, U.S.	98	66	72
Philadelphia, U.S.	70	47	27
Washington, D.C., U.S.	96	86	44
Pittsburgh, U.S.	80	70	29
New York City, U.S.	97	63	31
Ankara, Turkey	75	57	52

[1] Organisation for Economic Cooperation and Development
Source: OECD (1973a).

tern? Evolution in a direction does not, however, demonstrate its economic superiority or inevitability for a very good reason. The U.S. in particular has encouraged dispersal by a converging set of market imperfections and by public policy (Edel, 1973). The market incentives for using automobiles and for changing the urban form, and public policies on home mortgage and transportation facilities investment in the U.S. have all played a part in this process, although the private preference for and the efficiency of low density peripheral living are not all that clear.

In any case, the environmental and natural resource implications of low density urban form are a source of some concern. First, a low density sprawling metropolitan area is more extravagant of land than a compact metropolis for populations of the same size.

Second, there are two kinds of transportation implications. The more compact urban form requires less movement. It has been clearly established that the number of vehicle trips per capita in U.S. cities declines with increases in urban density (Smith, 1968).[16] The second effect of urban form is the lower potential for mass transit in the low density urbanized areas. The transit share of urban trips steadily increases with urban density. The joint effect of both these implications of low density development on transportation is to increase the level of overall travel and the proportion of automobile travel—both of which are likely to increase the energy consumption and emissions of mobile air pollutants such as CO, NO_x and HC.[17]

The contribution to *urban* air pollution from this increased vehicular travel associated with low density urbanization can be significant. Automobiles account for most of the emissions of oxides of carbon, nitrogen, and hydrocarbons into the atmosphere over twelve major OECD cities (Table 6). An analysis of potential air quality responses to changes in the current land development patterns in Boston suggests that a *centralization* scenario leads to reduced number and average length of auto trips, increased use of public transit, and *reduced* discharges of CO, HC, and NO_x (Ingram and Fauth, 1974). A decentralization scenario leads to increased overall emissions, slightly improved central city air quality and slightly degraded suburban air quality. The evidence on pollution from stationary source pollutants (SO_x particulates—from industries and power production) is somewhat more clouded. Small, low density, dispersed urban areas have the lowest TSP and SO_2 concentrations, if all other factors are held constant (Berry *et al.*, 1974; Keyes, 1976).

The evidence is somewhat clouded on the relationships between urban form and collection and disposal systems for sewage and solid wastes. In general, both of these, as well as gas and electricity collection and delivery systems, are more efficient with density, but may require higher costs thus offsetting the advantages. Low density has advantages for individual sewer systems or landfill disposal of garbage. However, extensive recycling of wastes and the solid waste recovery that may be required in the future would suggest large scale operations. Compact high density urban areas may make it easier and less costly to dispose of sewage treatment byproducts or to recover solid waste materials (Roy and Lakshmanan, 1974; Keyes, 1976).

Energy savings can be significant in compact cities. First, small to medium-sized multifamily housing units are thermally more efficient than single family detached homes characteristic of low density suburbs (Figure 15). It has been estimated that about 0.20 quadrillion BTU's of energy can be conserved annually in the U.S. in 1985 with a reasonable shift of the new housing stock toward multifamily units (Keyes and Peterson, 1976). The energy savings are considerable in the transportation sector with resulting increased urban density, particularly in the U.S. where the larger cars and lower occupancy levels make transportation more energy-inefficient as compared with another high income country, Sweden.

Low density urban development, on the other hand, has a definite advantage with respect to noise. The available evidence on the issue of urban form and environmental quality does not appear to be unambiguous. Given the current concern for energy conservation and environmental pollution abatement, *the overall balance tilts towards more compact urban areas than now exist, if we wish to improve urban environmental quality.*

If this presumption is valid, public policy should work toward a redefinition of the structure of economic incentives and legal regulations such that denser urban patterns are also viable in the urban areas. Economic incentives to encourage compact urban form would include greater tax and credit incentives for central city living, new utility pricing schemes, and public investment to improve housing, education, health, and other services in the central urban areas. In addition, there is a need to revise existing land use regulations that tend to

[16] Part of this reduction may also be attributable to the substitution of more walking trips in high density areas which are not included in the trip frequency data (Peterson *et al.*, 1976).

[17] One can argue that in low density development job decentralization accompanies work decentralization and that travel time for work trips may drop (Hoover, 1968; Zahavi, 1976). However, the latter may be absorbed by increased induced travel to other destinations (Peterson *et al.*, 1976).

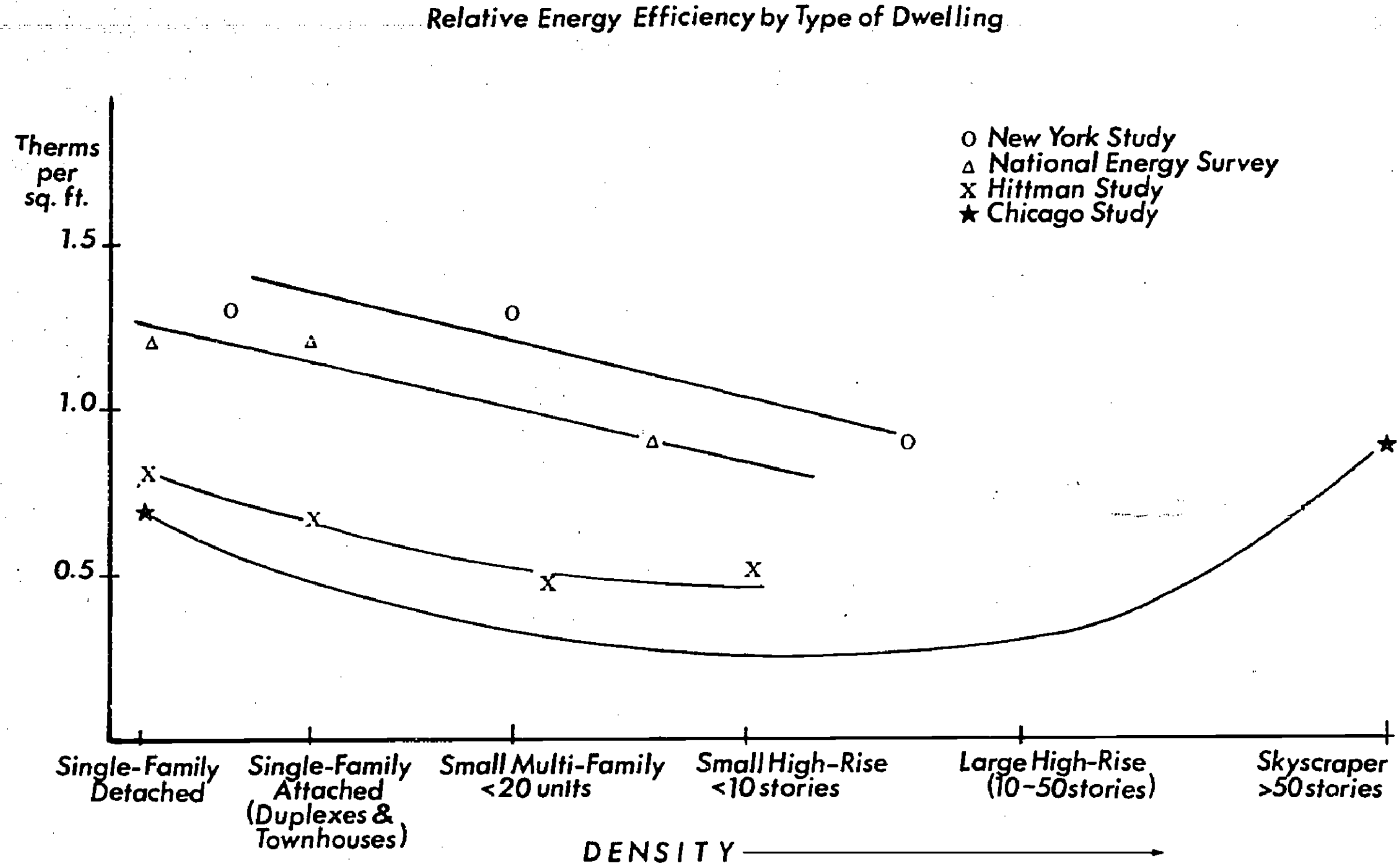


Figure 15. Relative Energy Efficiency by Type of Dwelling (Source: Keyes and Patterson, 1976).

lock the poor and racial minorities into specific sections of the metropolis. In the pursuit of one set of social goals, e.g., stabilization of property values or environmental quality, American communities erected a variety of zoning regulations and growth management techniques such as emission density ceilings or sewer moratoriums (Ramapo, New York) that have the effect of denying equal access to housing for all social groups. These exclusionary regulations developed in the name of environmental quality are not only a serious equity issue but also discourage energy-efficient, environmentally sound, compact urban forms.

If such steps are taken to narrow the differences in allure between central and peripheral areas, a more unfettered set of consumer preferences regarding urban density may be revealed. A variety of urban development patterns, ranging from high to low density, may become feasible in the metropolitan areas of the affluent societies.

V. THE URBAN ENVIRONMENT IN LOW INCOME SOCIETIES

The quality of the urban environment in the low income countries that are currently experiencing urbanization, unprecedented both in scale and speed, is a source of serious international concern. The litany is familiar—the squalor of rapidly proliferating slums, congestion in the streets, pollution of the environment, inadequacy of water supply and sewer systems in many neighborhoods. Between forty and seventy percent of the population of the fastest growing cities in the developing world are densely housed in variations of squatter settlements, without security of tenure, safe water, or basic sanitation. In Lima, Peru and Caracas, Venezuela, for instance, it is estimated that forty percent of the population live in unserviced settlements; this proportion is almost fifty percent in Mexico City; in Abidjan, Ivory Coast, and Bogota, Colombia, it climbs to sixty percent. Nearly 250 million urban dwellers are living in this manner and their numbers are growing by roughly twelve million persons per year (Jaycox, 1977). Such adverse environmental quality is not only characteristic of fast growing urban areas of the developing world but also of slow growing urban areas such as Calcutta, India (Chatterjee, 1976). In Calcutta, seventy-nine percent of the families live in a single room, 1.8 million people live in slums, sixty-one percent have no bathrooms, thirty to fifty persons share a single latrine, and sixty-two percent have no regular water supply.

Although these environmental characteristics are reminiscent of the conditions of nineteenth-century European and American cities, the context of the contemporary urbanization process is notably different from that of the Victorian era. The rapid urbanization in Europe and North America in the last century occurred when these countries had a lower population base and growth rate, higher per capita incomes, and a lower backlog of physical and medical technology than the developing countries today. The different initial conditions at the early stages of urbanization in the presently developing world define a different context of urbanization, that has profound environmental implications.

The Context of Contemporary Urbanization

Demographic Component

The demographic features of the urban transformation in the advanced countries has been described in detail (Davis, 1968). Rapid urbanization occurred in these countries in the context of relatively low national population growth rates—typically on the order of .5 percent per annum. In contrast, urbanization is occurring in the developing countries today accompanied by national population growth rates of 2.5 to 3.0 percent per annum.

These higher rates translate into (a) a large natural increase in urban population, and (b) a high rural to urban migration. Natural increase accounts for approximately fifty percent of the growth of urban areas in most developing countries. By contrast, urban growth in advanced countries in the corresponding period was largely because of rural to urban migration, since urban infant mortality rates were high. This combination of natural increase and inmigration leads to explosive growth rates in individual cities. It has been estimated that Seoul, South Korea has been growing at about nine percent per annum, Jakarta, Indonesia at 6.7 percent, Mexico City at six percent. If present demographic trends continue for the next two decades, cities of the developing world may double in size every twenty years, resulting in the near future in very large agglomerations (Beier *et al.*, 1975). The United Nations estimates the year 2000 population of these three cities at 18.71 million, 17.8 million, and 31.5 million, respectively (United Nations, 1974).

This rapid growth rate of large urban centers poses one of the more serious threats to environmental quality, since it does not allow the gradual emergence of appropriate planning and institutions for environmental quality management. Thus, even in countries such as India where the urbanization process is less advanced, the explosive growth of the large cities continues to pose serious problems.

Resource Characteristics

The severity of the task of ameliorating urban environmental problems stems not only from the rapidity of urban growth but also from the shortage of resources. The central fact is that people are poor in developing economies—in fact, poorer than people in today's developed economies were at the corresponding stage. Europe, on the eve of industrialization, was economically well beyond the level of contemporary societies in similar situations. In England and Wales, the per capita income was $175 (1968 dollars) in 1700 and $250 in 1750 (Landes, 1969). Comparable figures have been estimated for eighteenth-century France. By contrast, in 1970 South Korea had a per capita income of $250, India $110, Thailand $200, and Colombia $310.

This low level of income poses two kinds of problems. First, the quality of services largely reflects the limited ability of individuals to pay for services. Poor environmental quality is a natural consequence of low incomes, for the urban poor are unable to afford even minimal shelter or limited water supply, sewer service, and electricity. Poverty is common to both rural and urban areas, as it is an outgrowth of the national economy. However, the environmental problems resulting from poverty tend to focus on cities (as outlined in Chapter Two).

Second, a variety of environmental problems result from the manner of providing urban families with environmental services. For example, in many developing countries these problems stem, to some degree, from investment and pricing biases in service provision (reflecting priorities of people with economic and political power). These biases in turn distort the provision of environmental services. Urban investments, especially those associated with sewer, water, or transportation networks, are lumpy. By making lumpy investments inconsistent with the level of available national resources, urban managers have further aggravated the deterioration of environmental quality. Large investments increase the cost of the resulting services, which in turn excludes the urban majority from access to environmental services. The pricing bias results from the frequent practice of providing water supply and sewer systems free or at below cost to selected urban residents—leading to overuse and waste by some and under-supply for others.

Service Standards

The third factor underlying the current status of urban environmental quality is the choice of environmental standards guiding urban investment decisions. The rapid pace of contemporary urban development is accompanied by an explosive demand for a large variety of public services. Advanced economies in the last century not only encountered a slower rate of population growth but set in motion improvement in quality of environmental services incrementally as engineering and medical science made progress (Chapter One). The developing countries, on the other hand, have all this technical know-how, and the recommendations of national and international bodies urging the attainment of various desirable standards, yet they lack the resources to implement them to any great degree.

It is indeed true that water supply or sewer systems standards—higher than those experienced in any affluent economies at their corresponding period of growth—lead to dramatic improvements in health and productivity. Given limited natural resources, these higher standards can be made available only to a few, with correspondingly poorer standards or even exclusion from any service for most urbanites.

Moreover, in the last century, all the components of environmental conditions were improved simultaneously (but incrementally). Improvement of water supply was accompanied by improvements in sewerage systems and in solid waste collection and disposal. In contrast, in the developing countries today there is often a strong impetus to improve water supply conditions quickly, largely ignoring other sectors such as housing investment and solid waste disposal (Burton and Lee, 1974). Consequently, this emphasis on one aspect—water supply—of the urban environment poses further distortions leading to rapid growth of squatter settlements, outside water supply service boundaries, without the benefit of water or sewerage facilities.

The state of the urban environment in developing countries can be described along several dimensions. This chapter limits itself to a few key indicators: housing services, water supply, sewer services, and solid waste disposal. These four services deriving from the built environment constitute what economist Barbara Ward calls the basis of the "First Environmental Revolution" that made possible the emergence of large cities on a large scale in the developed countries in the last century.

Housing

The conditions of housing vary widely among the developing countries. Although the reasons for this variation are many and complex, as indicated earlier, the dominant factor governing the quality of housing is the income level of the populace.

The housing indicators displayed in Table 7 bear out this broad relationship. In general, the higher income countries in each group—developed or developing—consume a higher level of housing services for that group. Thus the U.S. has the highest per capita housing among the developed countries and the relatively high income developing countries in Latin America such as Venezuela consume more housing.

The relatively high income developing countries invest a higher proportion of their gross fixed capital formation (GFCF) and gross domestic product (GDP) in housing and employ a larger portion of the labor force in construction than the lower income developing countries. In general, they also enjoy better average housing conditions, as shown by the facts that their dwellings are less crowded and that more of the urban population is served with water supply (from standpipes of house connections) and sewer service (public or household systems). For example, India, Tanzania, and Sri Lanka, which have very low per capita incomes, have the lowest proportion of their urban population served by water supply or sewer service. They also have a higher proportion of urban homes with more than three persons per room. Most of the developing countries appear therefore to suffer from two handicaps: a rapid increase in population and severe limits on the resources that can be channeled into residential construction. International comparisons suggest that housing does benefit from increases in income over time but not in proportion to other goods and services at the highest income levels.

The distribution of income among urban households determines the number of families with different levels of income and ability to pay for housing. In particular, it identifies the poor households and the degree of their poverty. Figure 16 displays the distribution of income among urban households expressed in U.S. dollars (1970), obtained from household surveys in Ecuador. Less than thirty percent of households have an annual income of more than $1,000. The household monthly expenditures on housing corresponding to the household incomes have been estimated and displayed in Figure 16. The cost of the cheapest housing that a family can afford corresponding to such monthly payments are also shown.

The most striking aspect of Figure 16 is that housing costing in excess of U.S. $1,100 are beyond the reach of the bottom fifty percent of the urban population in Ecuador. Such a price is below the cheapest conventional housing being built and can obtain only "low amenity type" site and services. Only urban households in the top twenty percent of the income distribution in Ecuador can afford housing valued in excess of U.S. $2,100. Thus, the dwellings built in Ecuador up to the early 1970's with the support of the Inter-American Bank for Housing (IAB) and the U.S. Agency for International Development (USAID) priced on an average of U.S. $2,000 and $3,000, respectively, would add only to the higher value housing stock.

Such wide gaps between the cost of currently produced housing and the ability of low income families to pay are evident in a number of developing countries. Between thirty and seventy percent of the urban households in six other countries—India, the Philippines, Indonesia, Tanzania, Costa Rica, and Honduras—cannot afford the price of currently provided housing. The World Bank found that, in the six cities studied (see Table 8), the cheaper housing units currently produced by the public sector could not reach from thirty-five to sixty-eight percent of the urban residents.

Water Supply

Figure 10 (Chapter Two) indicated considerable variation among the developing countries in the proportion

TABLE 7. HOUSING INDICATORS FOR SELECTED COUNTRIES

Country	Urban/ total population* (% 1970)	GDP per capita 1970 (U.S. $, 1970)	Housing consumption per capita (U.S. $, 1970)	Residential investment as % of GDP (1963-1973 average)§	Residential investment as % of GFCF (1963-1973 average)§	Labor force in construction‖ (%)	Percentage of occupied urban dwellings with three or more persons per room‖	Urban population without water systems¶ (%)	Urban population without public or household sewer systems¶ (%)	Population in squatter settlements in the largest city (%)
Developing countries										
Brazil	55.0	420	N.A.	6.7**†† (1963-1969)	41.8**†† (1963-1969)	N.A.	2.8 (1969)	23.0	15.0	30 (Rio)
El Salvador	38.7	300	17.1	2.6 (1968-1972)	17.6 (1968-1972)	4.1 (1961)	50.2 (1971)	23.2 (1961)	37.0	
Venezuela	78.8	980	159.6	5.5 (1968-1972)	22.6 (1968-1972)	6.5 (1970)	21.1 (1961)	8.0	43.0	40 (1969)
Portugal	27.9	660	30.2	3.9	20.8	6.7 (1960)	10.3 (1960)	N.A.	N.A.	
Ghana	35.9	310	36.0	7.3 (1968-1972)	63.4 (1968-1972)††	3.3 (1960)	N.A.	27.0	N.A.	53 (1968)
Kenya	10.0	150	N.A.	2.5 (1964-1973)	14.5 (1964-1973)		41.1 (1962)	3.0	0.0	
Tanzania	6.0	100	10.5	N.A.	N.A.	N.A.	N.A.	55.0	69.3 (1958)	58 (1970)
India	20.3	110	6.4	2.7 (1963-1971)**	8.72 (1963-1971)**	1.1 (1961)	N.A.	44.0	20.0	33 (1971)
Malaysia	27.3	380	16.5	1.8	12.9**		52.2 (1960)	29.1 (1960)	6.4 (1960)	37 (1971)
Sri Lanka	22.0	110	12.8	7.4	47.9‡‡	2.5 (1963)	N.A.	40.0	8.0	24 (1968)
South Korea	41.5	250	16.7	2.81	12.1		46.6 (1960)	12.0	38.0	30 (1970)
Thailand	14.8	200	8.8	3.2	13.9	0.5 (1960)	N.A.	40.0	34.0	
Colombia	55.0	340	N.A.	2.9	16.8		N.A.	12.0	25.0	
Chile	76.7	720	N.A.	2.6†	17.1		22.7 (1960)	31.0	N.A.	
Developed countries										
United States	74.0	4760	553.1	3.6 (1968-1973)	20.8 (1968-1973)	6.3 (1971)				
United Kingdom	77.7	2270	230.3	3.2	18.2	7.8 (1966)				
West Germany	81.3	2930	182.3	5.6	12.8	7.4 (1971)				
Japan	53.2	1920	111.7	6.5	19.1	7.6 (1970)				
Australia	84.8	2820	270.1	5.0	19.2	8.8 (1966)				
France	72.8	3100	196.5	5.1 (1970-1971)	24.5 (1970-1971)	9.1 (1971)				

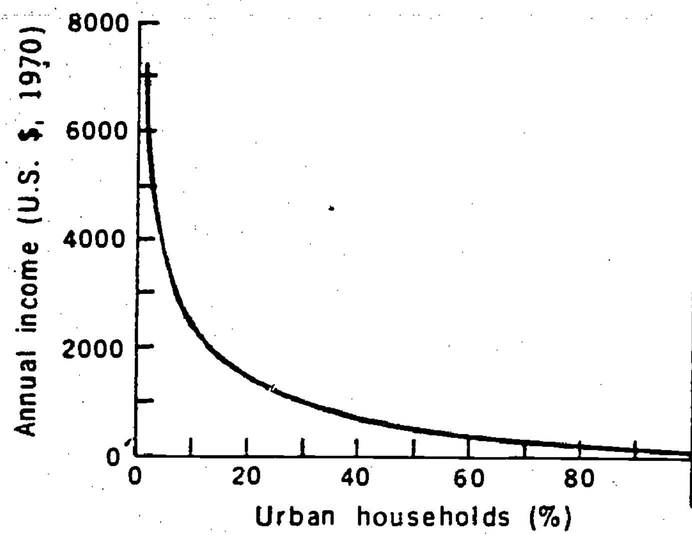
* United Nations Populations Division, October 1974. § Figures in parentheses indicate years over which data are averaged. ¶ Data are for 1970 unless otherwise indicated. ** Data for El Salvador, Malaysia, Brazil, and India are based on current prices; for all other countries constant prices are used. †† Investment data for Ghana and Brazil include all categories of construction. ‡‡ Investment data for Sri Lanka include residential and nonresidential construction. N.A. Not Available.
Source: Lakshmanan *et al.* (1976).

of their urbanites receiving piped-in water. In general, the greater the per capita income of a country, the larger proportion of the urban population likely to receive a piped-in water supply. Other factors besides per capita income influence the level of urban water supply. One of these is the pace of urban growth. Where the pace of urbanization is very rapid, the financial and management resources for the provision of water supply are strained to a point that the proportion of the urban population receiving piped-in water supply declined (as in Argentina, Brazil, Chile, Colombia, and Peru) between 1962 and 1970. In the African and Asian societies which are urbanizing more slowly, the proportion of urbanites served by water increased in the 1960's.

Another factor is the role of water supply standards set by public health specialists, commonly water supply engineers. These standards, set from the perspective of controlling diseases, are often counterproductive and tend to restrict the number of persons with access to urban water supply (Burton and Lee, 1974).

Information on the question of access of urban populations to water supply is fragmentary; however, case study information exists for three cities: Bogota and Cartagena, Colombia and Mexico City, Mexico (Hubbell, forthcoming). Access was measured in terms of percent of occupants with selected services. Table 9 shows that there was a significant relationship between percent of people receiving a service and the average income of the households. The higher the income of a neighborhood, the greater the percent of population served. Since the data for Cartagena came solely from low income neighborhoods, the results show that in relatively low income neighborhoods, the relatively higher income groups have better access to public utilities.

Data from the Bombay (India) Metropolitan Area (BMA) also corroborate this view. Though the poor are heavily concentrated in the core city, which is sewered and has piped water, careful examination shows that this area of the city has also the fewest metered residents and the largest percentage of nonmetered households in BMA (seventy-three percent are not metered, as compared to twenty-five percent in the near suburbs and thirteen percent in the outer suburbs). Similarly, even in the part of Bombay where ninety-five percent of the population is sewered, the areas where the poor live have inordinate numbers of privies without running water (Hubbell, forthcoming).



Monthly income	Monthly house payments*	Cost of affordable housing†	Remarks
500	80	8900	
250	40	4500	
			U.S.A.I.D. average
140	21	2310	
90	14.5	1500	Inter-American Bank type average
40	8	900	Site and services (low amenity)

*Percentage of monthly income devoted to housing, varying between 15 and 20 percent among different groups.
†Based on 25-year repayment, 10 percent interest (U.S. $, 1970).

Figure 16. Urban Income Distribution and Affordable Housing, Ecuador.

Sewer Service

The extent to which sewage is conveyed from its source, treated, and ultimately disposed of in an urban area depends on the costs of the necessary facilities and the ability of the population to pay for them.

From the point of view of abatement of environmental pollution, a waterborne sewer system with treatment is considered most desirable and is most expensive. At the other end are inexpensive household systems where the domestic wastes are received and disposed of without treatment. In the developed countries, and in the central parts of large urban areas of many developing countries, the waterborne sewer system with treatment is the prevalent mode. But a large proportion of urban residents in the developing world and in outlying parts of urban areas observed do not have sewer service. Instead, they have a variety of household systems such as septic tanks, pit privy, or buckets, or none at all.

Figure 11 (Chapter Two) displays the level of sewer service provided in urban areas of selected developing countries, based on data from a World Health Organization (WHO) survey. Sewage disposal could include collection and disposal with or without treatment in waterborne systems, and use of household systems such as pit privies, septic tanks, and buckets.

Thus we can draw two conclusions from Figure 11. First, less than twenty-five percent of the population is connected to public sewers. No records are available on the percentage of effluent served treated. In general, however, the effluent is delivered untreated to a convenient body of water—a river, bay, or ocean. Second, household systems account for the greater part of the system. This type of waste disposal is extensively used throughout Southeast Asia.

Solid Waste

Solid wastes in urban areas are derived mainly from the consumption activities of households, commercial establishments, and industries. The generation of solid wastes increases as incomes increase, but at a smaller rate than income growth.

As Hanayama (1974) has indicated, the composition of household waste varies in accordance with household expenditure pattern differentials and differences in the economic structure and milieu of the societies to which the households belong. In general it may be noted that some classes of waste, such as glass, paper, metal, and plastics, grow rapidly with growth in income. This increase in the proportion of essentially lighter material, in comparison with the decline in the proportion of rela-

TABLE 8. COST OF CHEAPEST EXISTING HOUSING UNIT AND PERCENTAGE OF HOUSEHOLDS UNABLE TO AFFORD IT IN SELECTED CITIES

City	Cost of Unit (U.S. $, 1970)	Percentage of Households Unable to Afford Unit at: Present Cost	50% Reduction
Mexico City	3005	55	37
Hong Kong	1670	35	14
Nairobi, Kenya	2076	68	53
Bogota, Colombia	1474	47	26
Ahmadabad, India	616	64	51
Madras, India	570	63	31

Source: World Bank (1975).

TABLE 9. SIMPLE CORRELATION ANALYSIS OF SERVICE ACCESS WITH INCOME IN BOGOTA AND CARTAGENA, COLOMBIA AND MEXICO CITY, MEXICO[1]

	Bogota		Cartagena		Mexico City	
Type of Service	Number of Observations	Correlation Coefficient[2]	Number of Observations	Correlation Coefficient[2]	Number of Observations	Correlation Coefficient[2]
In-house Water[3]	60	.539	14	.653	34	.597
Sewerage[4]	60	.253	17	.540	34	.679
Electricity[5]	60	.374	15	.629	34	.540
Water Supply[6]					34	.294

[1] Simple correlation coefficients (r) of service access with income.
[2] The relation is significant at the .05 level in the case of Bogota when r ≐ .35; in Cartagena for 14 observations r = .50 at the .05 level; for Mexico City the relation is significant at the chosen .05 level when r = .25.
[3] Percent of occupants or households with in-house water.
[4] Percent of households or dwellings connected to piped sewerage in the case of Bogota and Mexico City. Percent of households with water septic tanks in Cartagena; no piped sewerage is available.
[5] Percent of households with electricity.
[6] Percent of occupants with access to public water.
Source: Hubbell (forthcoming).

tively heavy garbage, is reflected in the lighter solid waste in more developed countries.

With increasing affluence the proportion of paper, metals, glass, and plastics tends to increase for two reasons. First, as noted earlier, with increasing affluence there is a propensity towards the increased production and consumption of paper, glass, metal, and plastic products and packaging. This difference is noticeable in the changing composition of solid wastes collected in Sao Paulo, Brazil and in Washington, D.C. (Table 10). Second, with increasing affluence there is a decreasing propensity to salvage and recycle material from waste. In less developed economies, the value of reclaimable material salvaged from household or business refuse is relatively high. There are inherent market mechanisms that take care of reclaimable material like paper, rags, and glass bottles prior to their disposal as solid waste. This in turn is reflected in the relatively low proportions of paper and glass in the municipal solid waste collected in less developed countries. It may be postulated that the available solid waste data are *a posteriori* insofar as reclaimable material has already been salvaged. Since the bulk of reclaimable material has been salvaged prior to its disposal as household solid waste, the relevance of waste composition vis-à-vis salvage and recycling may be questioned in low income countries.

TABLE 10. CHANGE IN COMPOSITION OF MUNICIPAL SOLID WASTE

Sao Paulo[1]	1927	1957	1969
	(%)	(%)	(%)
Paper	13.4	16.7	24.7
Cartons	—	—	4.5
Tin	1.3	2.1	7.8
Glass	0.9	1.4	2.6
Plastics	—	—	1.9
Organic Matter	82.5	76.0	52.2
Others	1.9	3.8	6.3
	100.0	100.0	100.0

Washington, D.C.[2]	1914		1956	
	May	Dec.	May	Dec.
	(%)	(%)	(%)	(%)
Paper Products	42.0	47.3	60.4	68.3
Metals, Cans	10.4	8.3	13.1	10.8
Glass	12.9	11.6	16.3	11.5
Rags	7.2	3.7	0.8	0.5
Others	27.5	29.1	9.4	8.9
	100.0	100.0	100.0	100.0

[1] Lixo e Limpeza Publica—Universidade de Sao Paulo, Faculdade de Higiene e Saude Publica, Organizacao Mundial da Saude, Organizacao Panamericana da Saude—Sao Paulo—Brasil—1969.
[2] Municipal Refuse Disposal—APWA Research Foundation Project 104 (1961).

Resources for Urban Environmental Improvement

Rising per capita income levels and improved income distribution may eventually improve the condition of housing, water supply, sewer service, and solid waste collection. But what is the outlook for such improvement in the cities of the developing world in the next two or three decades? To address the issue briefly, a summary description of the United Nations World Model should be useful.

This model was used for analyzing the resources available and implications for urban housing, sewer, water supply, and solid waste collection (Lakshmanan *et al.*, 1976). What follows here is an illustration in the area of housing.

The United Nations Model

The U.N. World Model of the world economy was developed by a team headed by Professor Wassily Leontief to help member states assess the impacts of environmental issues and policies on international economic development, and to improve our understanding of the effects of alternative development policies. Such an improved understanding may help solve certain conflicts believed to exist among the goals of improving living standards worldwide, improving the quality of the environment, and conserving scarce natural resources. The model is an interregional (fifteen-region) input-output model of the world economy that also provides a description of natural resource requirements, environmental pollution, pollution abatement costs, and urbanization costs.

The model can be used flexibly to estimate the requirements of meeting specified levels of a wide variety of target variables. We can estimate the levels of GDP and growth rates that are consistent with specified limits of capital supply, and labor force and productivity constraints in the developing world. Alternatively, given the population (total and urban) and GDP levels, we can also make estimates of the levels of production, labor, and housing investment needed to sustain them. The specific answers will, of course, depend on simultaneous assumptions made about such matters as population growth, environmental and amenity standards, foreign aid capital transfers, and the like, all of which can be introduced as alternative development scenarios.

Input structures for the urban sector are introduced into the model on the basis of cross-national studies of housing and urban environmental amenities—water supply, sewer system, solid waste collection and disposal. This was the first time that the urban segment was encompassed within the framework of the input-output model.

A cross-national analysis of the relationships among per capita income, housing consumption, and investment was carried in the framework of the World Model (Lakshmanan *et al.*, 1975). Table 11 presents the estimates of urban housing investment for the two decades 1970-1990. These estimates represent the levels of regional housing investment that can be sustained by the levels of projected GDP per capita, and personal consumption per capita in 1980 and 1990. There is no absolute limit to the resources that can be made available for investment in housing stock (except in the short run), and what a nation can afford is a matter of social choice and national housekeeping. If other competing public and private purposes are not to provide any new patterns of subsidy to housing, these estimates can be viewed as the level of national resources available for adding to the stock of housing over the next two decades. Further, a parallel estimate is made of the number of housing units that would be needed in the same two decades, given the projections such as urban population, per capita income, family size, and replacement rates. These estimates appear in Table 11.

Implications for Environmental Policy

Table 11 provides a comparison between the resources available and the number of dwelling units required for urban housing for the two decades 1970-1980 and 1980-1990. We characterize the degree of match between resources and needs by two simple measures. The first measure represents the average cost of a dwelling unit if all the housing needs are to be met by the available resources. These costs do not include land costs, which represent between twelve and forty-six percent of the total cost of a dwelling in some developing countries and between eighteen and twenty-six percent in a high income economy such as the United States. In the two relatively higher income developing regions of Latin America (regions X and XI), half the dwelling units to be built in the 1970's, to meet the estimated needs, would be under $2,500. In the poorer Asian region, half the new units to be built should be under $1,000. In the African region, the average cost of the dwelling unit should be even lower, less than $800.

TABLE 11. RESOURCES AND NEEDS OF URBAN HOUSING, 1970-1990

	1970-1980				1980-1990			
Region	Urban housing investment (billions of U.S. $, 1970)	Urban housing requirement (millions of dwelling units)	Average dwelling unit cost (land costs excluded) (U.S. $, 1970)	Cost per dwelling unit to serve the poorest 25% of urban households must be under (U.S. $, 1970)	Urban housing investment (billions of U.S. $, 1970)	Urban housing requirement (millions of dwelling units)	Average dwelling unit cost (land costs excluded) (U.S. $, 1970)	Cost per dwelling unit to serve the poorest 25% of urban households must be under (U.S. $, 1970)
Developing regions, Class II								
1. Latin America (medium development)	37.375	14.903	2,508	1,287	66.959	22.509	2,974	1,776
2. Latin American (low development)	15.252	6.498	2,347	1,151	32.228	11.050	2.916	1,641
3. Asia (China)	16.821				35.465			
4. Asia (low development)	17.426	16.496	1,056	534	43.328	31.870	1,360	781
5. Africa (arid)	2.332	2.764	844	455	4.885	3.726	1,311	761
6. Africa (tropical)	1.829	2.315	790	434	6.279	4.700	1,336	771

Source: Lakshmanan *et al.* (1976).

These figures would suggest, in light of the evidence from Table 11 and elsewhere, that a significant portion of urban households in the 1970's will not be able to afford even the cheapest low cost housing currently being produced. The increase in real income in the 1970's is not expected to be significant enough to permit that. It is expected that in the 1980's households in these regions will be able to afford dwelling units of higher average cost. However, in most cases, the increasing average cost of affordable units will very likely outstrip the rate of increase in real income, which will not be adequate to bring cheap housing within the financial reach of those in the low income regions.

The second measure is an estimate of the minimum cost of the dwelling unit that is beyond the reach of the poorest twenty-five percent of the urbanites, and this figure is even more telling. In the Asiatic and African regions, if the needs of the bottom twenty-five percent of the population are to be met, dwelling units must be available at less than $500 (exclusive of land costs). (Even in the richer Latin American regions, the cost of such units must be under $1,000 to $1,200.) It is expected that in the 1980's this segment of the urban poor will be able to afford slightly more expensive homes (up to $750). Even so, they will not be able to afford the cheapest currently available housing units.

It appears, therefore, that, although the 1970's and 1980's will probably be a time of higher per capita incomes and increased resources for urban housing, the currently observed mismatch between the ability of the low income urban families to pay for housing and the cost of currently produced dwelling units is not likely to change very significantly. The poorest twenty-five percent of the urban population is unlikely to be able to pay the economic cost of currently produced low cost housing to the end of the 1980's in the Asian and African regions. It is imperative to reduce housing costs to levels attainable by the majority of the urbanites.

An obvious and direct method of reducing costs is to reduce the standards of dwellings. Material standards can be reduced if cheaper indigenous materials and construction are substituted for higher cost materials. Modest space standards can be accepted. Lower service levels—shared kitchens and sanitary facilities—can further lower the cost. Additional savings are possible if the land area devoted to buildings is reduced.

Such reduced standards as shared sanitary facilities and kitchens are currently manifest in the poorer sections of cities in developing countries. What we are suggesting here is that a formal recognition of lower standards can greatly help in incorporating safety and health considerations into these market-induced standards. Such a formal recognition will permit a more effective organization and provision of urban amenities in areas where residential capital formation from domestic savings of the low income sector is already occurring.

There is evidence to suggest that with lower standards (shared services and multifamily buildings) housing can currently be made available for the bulk of the urban population in the peripheral areas of cities of higher income countries (Latin America and selected countries in Asia). If the countries in these regions attach priority to housing low income groups in the 1970's and 1980's, they must be willing to reduce space, material, and service standards at the peripheral and intermediate locations in the city.

In the Asian and African regions, even such reductions in standards may still leave the bottom twenty-five percent of the urbanites unserved. The low incomes of the people in these countries make any substantial subsidies to the urban poor unlikely. For them, even more resource conserving approaches are required. Our analyses would suggest, therefore, general support for the application on a broad scale of experimental resource conserving approaches being tried out on a small scale by some international aid agencies. Among these are the minimum shelter core housing approach of the Federation for Cooperative Housing (USAID) and the World Bank's site services projects (in which low income families are provided with land and public utility components of the housing package with assistance in self-help building) and upgrading squatter housing (improving existing low income housing stock and its service).

In summary, this chapter suggests that, if national resources are to be used efficiently and equitably, particularly in the developing countries, strategies to match resources and needs are imperative. An important part of such a strategy is to arrive at decisions about the environmental standards at which to aim, the rate at which general advance toward them should be achieved, and the most suitable forms for their attainment, in light of the best possible knowledge of the effects of available alternatives. Here we have provided some broad indicators that can be explored in the specific context of individual countries.

BIBLIOGRAPHY

Alonso, William (1970) *The Question of City Size and National Policy*, Berkeley: University of California, Institute of Urban and Regional Development, Working Paper 125.

American Public Works Association (1969) *Water Pollution Aspects of Urban Runoff*, Washington, D.C.: FWPCA, Water Pollution Control Research Series, January.

Atkinson, Arthur and Ira Robinson (1969) "Amenity Resources for Urban Living," in H. Perloff (ed.), *The Quality* *of the Urban Environment,* Baltimore: The Johns Hopkins University Press for Resources for the Future, Inc., pp. 179-201.

Ayres, Robert and Allen V. Kneese (1969) "Pollution and Environmental Quality," in H. Perloff (ed.), *The Quality of the Urban Environment,* Baltimore: The Johns Hopkins University Press for Resources for the Future, Inc., pp. 35-71.

Babcock, Richard F. and Fred P. Bosselman (1970) "Conflicts in Land Use," in D. M. McAllister (ed.), *Environment: A New Focus for Land Use Planning,* Washington, D.C.: U.S. Government Printing Office, pp. 143-155.

Bach, Wilfrid (1972) "Urban Climate, Air Pollution and Planning," in T. R. Detwyler and M. G. Marcus (eds.), *Urbanization and Environment,* Belmont, CA: Duxbury Press, pp. 69-96.

Beier, George, Anthony Churchill, Michael Cohen, and Bertrand Renaud (1975) *The Task Ahead for the Cities of the Developing Countries,* Washington, D.C.: World Bank Staff Working Paper No. 209, July.

Bell, Gwen, ed. (1976) *Strategies for Human Settlements; Habitat and Environment,* Honolulu: University Press of Hawaii.

Berry, Brian J. L. and Frank E. Horton (1974) *Urban Environmental Management,* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Berry, Brian J. L. *et al.* (1974) *Land Use, Urban Form and Environmental Quality,* Chicago: University of Chicago, Department of Geography Research Paper No. 155.

Berry, Brian J. L. *et al.* (1977) *The Social Burdens of Environmental Pollution: A Comparative Metropolitan Data Base,* Cambridge, MA: Ballinger.

Boulding, Kenneth E. (1966) "The Economics of the Coming Spaceship Earth," in Henry Jarrett (ed.), *Environmental Quality in a Growing Economy,* Baltimore: The Johns Hopkins University Press, pp. 3-14.

——— (1970) "Fun and Games with Gross National Product: The Role of Misleading Indicators in Social Policy," in H. W. Helfrich, Jr. (ed.), *The Environmental Crisis,* New Haven: Yale University Press, pp. 157-170.

Briggs, Asa (1968) "The Victorian City: Quantity and Quality," *Victorian Cities,* Summer, pp. 711-730.

Burton, Ian and T. R. Lee (1974) "Water Supply and Economic Development: The Scale and Timing of Investment," in L. Jakobson and Ved Prakash (eds.), *Metropolitan Growth,* Beverly Hills: Sage Publications.

Carter, Nicholas (1973) "Population, Environment and National Resources: A Critical Review of Recent Models," *Population Debate,* United Nations, Vol. II, pp. 222-231.

Chatterjee, Lata (1976) "The Calcutta Region: Problems, Planning and Development," *Focus,* Vol. 27, No. 1, Sept/Oct.

Clawson, Marion and Peter Hall (1972) *Planning and Urban Growth,* Baltimore: The Johns Hopkins University Press.

Clopper, Almon, Jr. *et al.* (1974) *Interindustry Forecasts of the American Economy,* Lexington, MA: Lexington Books.

Coleman, B. I. (1973) *The Idea of the City in Nineteenth-Century Britain,* London: Routledge and Kegan Paul, pp. 1-21.

Council on Environmental Quality (1970) *The First Annual Report,* Washington, D.C.: U.S. Government Printing Office.

——— (1972) *The Third Annual Report of the Council on Environmental Quality,* transmitted to Congress, Washington, D.C.: U.S. Government Printing Office.

Darmstadter, Joel (1971) *Energy in the World Economy,* Baltimore: The Johns Hopkins University Press.

Dave, J. M. (1975) "Basic Needs for Monitoring Air Pollutants in a Developing Country," in *Proceedings, International Conference on Environmental Sensing and Assessment,* Las Vegas, Nevada.

Davis, Kingsley (1968) "The Urbanization of the Human Population," in Gerald Breese (ed.), *The City in Newly Developing Countries,* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Detwyler, T. R. and M. G. Marcus, eds. (1972) *Urbanization and Environment,* Belmont, CA: Duxbury Press.

Edel, Matthew (1973) *Economies and the Environment,* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Freeman, A. M., III, Robert H. Haveman, and A. V. Kneese (1973) *The Economics of Environmental Quality,* New York: John Wiley & Sons.

Friedman, John (1973) "The Future of the Urban Habitat," in D. M. McAllister (ed.), *Environment: A New Focus for Land Use Planning,* Washington, D.C.: U.S. Government Printing Office.

Grimes, Orville F., Jr. (1976) *Housing in the Low Income Countries,* Baltimore: The Johns Hopkins University Press.

Greenberg, M. R. (1977) *Spatial Association of Cancer Mortalities in the New Jersey-New York-Philadelphia Metropolitan Areas,* draft report, New Brunswick, NJ.

Greenberg, M. R., G. W. Carey, L. Zobler, R. M. Hordon (1973) "A Statistical Dissolved Oxygen Model for a Free-Flowing River System," *Journal of the American Statistical Association,* Vol. 69.

Hall, Peter (1970) "Transportation," in Peter Cowan (ed.), *Developing Patterns of Urbanization,* Beverly Hills: Sage Publications, pp. 130-157.

Hanayama, Yuzura (1974) *Memorandum on Solid Waste,* New York: United Nations World Model Working Paper, March 28.

Hoch, Irving (1972) "Income and City Size," *Urban Studies,* Vol. 9, pp. 299-328.

Hoover, Edgar (1968) "The Evolving Form and Organization of the Metropolis," in H. Perloff and L. Wingo (eds.), *Issues in Urban Economics,* Baltimore: The Johns Hopkins University Press, p. 68.

House, Peter W. (1977) *Trading-Off Environment, Economics and Energy,* Lexington, MA: Lexington Books.

Hubbell, K. (forthcoming) "Pricing and Provision of Utilities in the Cities of Less Developed Countries," in T. R. Lakshmanan and L. Chatterjee (eds.), *Urbanization, Labor Absorption and Environmental Quality in Latin America.*

Ingram, Gregory K. and Gary R. Fauth (1974) *TASSIM: A Transportation and Shed Simulation Model,* Vol. 1, Washington, D.C.: Department of Transportation, May.

Jakobson, Leo and Ved Prakash, eds. (1974) *Metropolitan Growth, Public Policy for South and Southeast Asia,* Beverly Hills: Sage Publications.

Jaycox, Edward V. K. (1977) "Housing for the Poor: The Task Ahead in Developing Countries," paper presetned at the XV Inter-American Savings and Loan Conference.

Kain, John F. (1967) *Urban Form and Costs of Urban Services,* Cambridge, MA: Harvard University Press.

Kaiser, E. J. *et al.* (1974) *Providing Environmental Quality Through Urban Planning and Controls,* Washington, D.C.: U.S. Environmental Protection Agency.

Kapp, K. W. (1963) *Social Costs of Business Enterprises,* Bombay, India: Asia Public House.

Keyes, Dale L. (1976) *Metropolitan Development and Air Quality,* Washington, D.C.: Urban Institute, Working Paper 5049-16, November.

Keyes, Dale L. and George E. Peterson (1976) *Metropolitan Development and Energy Consumption,* Washington, D.C.: Urban Institute, Working Paper 5049-15, September.

Kneese, Allen V., R. V. Ayres, and Ralph C. d'Arge (1970) *Economics and the Environment, A Materials Balance Approach,* Washington, D.C.: Resources for the Future, Inc.

Kuznets, Simon (1973) "Modern Economic Growth: Findings and Reflections," *American Economic Review*, June, pp. 247-258.
Landes, David S. (1969) *The Unbound Prometheus*, Cambridge, England: Cambridge University Press.
Laquain, Aprodicio (forthcoming) "Housing Strategies for the Urban Poor," in T. R. Lakshmanan and L. Chatterjee (eds.), *Urbanization, Labor Absorption and Environmental Quality in Latin America*.
Landsberg, Helmut E. (1970) "Climates and Urban Planning," in *Urban Climates*, Geneva, Switzerland: World Meteorological Organization, Publication 254 (TP 141), Tech Note 1081, pp. 364-374.
Lave L. and E. Seskin (1970) "Air Pollution and Human Health," *Science*, Vol. 169, pp. 723-733.
Lakshmanan, T. R. (1975) "The Strategic Environmental Assessment System: An Assessment of Urban Environments in the U.S.," paper prepared for the American-Soviet Seminar on Environment of Present and Future Cities.
Lakshmanan, T. R., Lata Chatterjee, and Probir Roy (1975) "Urbanization and Environmental Quality," in Wassily Leontief *et al.*, *Study on the Impact of Prospective Environmental Issues and Policies on the International Development Strategy*, Technical Report prepared for the United Nations Department of Economic and Social Affairs, May.
Lakshmanan, T. R., Lata Chatterjee, and Probir Roy (1976) "Housing Requirements and National Resources," *Science*, Vol. 192, June, pp. 943-949.
Lakshmanan, T. R. and S. Krishnamoorti (1973) *The Strategic Environment Assessment System Model: Test Model*, prepared for the U.S. Environmental Protection Agency, August.
Lakshmanan, T. R. and F. C. Lo (1972) "A Regional Economic Model for the Assessment of Air Pollution Abatement," *Environment and Planning*, Vol. 4, pp. 73-97.
Lakshmanan, T. R. and Sam Ratick (1977) "The Economic and Environmental Effects of Energy Development Scenarios: A Strategic Assessment," paper prepared for the Joint American-Soviet Seminar on Urban Environment, Evanston, IL, May.
Lakshmanan, T. R. and Lata Chatterjee, eds. (forthcoming) *Urbanization, Labor Absorption and Environmental Quality in Latin America*.
Leech, Gerald (1973) *The Motor Car and National Resources*, Paris: Organisation for Economic Cooperation and Development, Environment Directorate.
Leontief, W. (1970) "Environmental Repercussions and the Economic Structure: An Input-Output Approach," *Review of Economics and Statistics*, August.
Leontief, W. *et al.* (1975) *Study on the Impact of Prospective Environmental Issues and Policies on the International Development Strategy*, Technical Report prepared for the United Nations Department of Economic and Social Affairs, May.
Leontief, W. *et al.* (1977) *The Future of the World Economy*, New York: Oxford University Press.
Leven, Charles L. (1968) "Towards a Theory of the City," in *Urban Development Models*, Washington, D.C.: Highway Research Board, Special Report 97.
Liu, Ben-Chieh (1975) *Quality of Life Indicators in the U.S. Metropolitan Areas*, prepared for the U.S. Environmental Protection Agency.
McGee, T. G. (1971) *The Urbanization Process in the Third World*, London: G. Bell and Sons.
McPherson, M. B. (1974) *Hydrological Effects of Urbanization*, Paris: UNESCO Press.
Meadows, Donnella H., Dennis L. Meadows, Jorgen Randers, and William H. Behrens, III (1972) *The Limits to Growth*, New York: University Books.
Miernyk, William (1965) *The Elements of Input-Output Analysis*, New York: Random House.
Mikesell, Marvin W. (1974) "Geography as the Study of Environment: An Assessment of Some Old and New Commitments," in I. R. Manners and M. W. Mikesell (eds.), *Perspectives on Environment*, Washington, D.C.: Association of American Geographers, pp. 1-23.
Mitre Corporation (1972) *National Environmental Indices: Air Quality and Outdoor Recreation*, Washington, D.C., MTR 6159, April.
——— (1974) *The PDI Index*, Washington, D.C., Working Paper 7963, September.
Neutze, G. M. (1965) *Economic Policy and the Size of Cities*, Canberra: Australian National University.
Oak Ridge National Laboratory (1971) *Oak Ridge Air Quality Index*, Oak Ridge, TN, September.
Organisation for Economic Cooperation and Development (1973a) *Effects of Traffic and Roads on the Environment in Urban Areas*, Paris.
——— (1973b) *Environmental Directorate, Environmental Implications of Options in Urban Mobility*, Paris, September.
Owen, Wilfred (1972) *The Accessible City*, Washington, D.C.: The Brookings Institution.
Patterson, Philip (1976) "Exposure to Dangerous Air Pollution Levels: The Impact on Various Socioeconomic Groups," paper presented at the Atlantic Economic Conference, Washington, D.C., October.
Patterson, Philip and Samuel Ratick (1975) "A Use of Comprehensive Analysis at the EPA," paper presented at the Atlantic Economic Conference Washington, D.C., September.
Perloff, Harvey S. (1969) "A Framework for Dealing with the Urban Environment: Introductory Statement," in Harvey S. Perloff (ed.), *The Quality of the Urban Environment: Essays on 'New Resources' in an Urban Age*, Baltimore: The Johns Hopkins University Press for Resources for the Future, Inc.
Peterson, George E., M. D. Cheslow, K. Neels, and M. L. Olsson (1976) *Travel Behaviour: Designing the Accessible City*, Washington, D.C.: Urban Institute, Working Paper 5049-17 (November).
Polenske, Karen R, (1972) "The Implementation of a Multiregional Input-Output Model for the United States," in A. P. Carter and A. Brody (eds.), *Input-Output Techniques*, Amsterdam: Elsevier North-Holland Publishers, pp. 171-189.
Polyani, Karl (1957) *The Great Transformation*, Boston: Beacon Press.
Real Estate Research Corporation (1974) *The Costs of Sprawl*, prepared for the Council on Environmental Quality.
Reilly, William R., ed. (1973) *The Use of Land: A Citizen's Policy Guide to Urban Growth*, New York: Thomas Y. Crowell.
Richardson, Harry W. (1973) *The Economics of Urban Size*, Lexington, MA: Lexington Books.
Rothenberg, Jerome (1970) "The Economics of Congestion and Pollution: An Integrated View," *American Economic Review*, May, pp. 114-121.
Roy, Probir and T. R. Lakshmanan (1974) *Urban Solid Waste: Generation and Disposal: A Comparative Analysis of the U. S., Western Europe, Japan and Latin America*, Baltimore: The Johns Hopkins Center for Metropolitan Research and Planning, Working Paper No. 2, September.
Schmidt, James A. (1974) "The Environmental Impact of Urbanization," in I. R. Manners and M. W. Mikesell (eds.), *Perspectives on Environment*, Washington, D.C.: Association of American Geographers, pp. 181-212.
Smith, Wilbur & Associates (1968) *Patterns of Car Ownership, Trip Generation and Trip Sharing in Urbanized Areas*, report

prepared for U.S. Department of Transportation, Bureau of Public Roads.

Stankowski, S. J. (1972) *USGS Annual Research*, Washington, D.C.: U.S. Government Printing Office, U.S. Geological Survey Professional Paper 800-B.

Stone, P.A. (1973) *The Structure, Size and Costs of Urban Settlements*, Cambridge, England: Cambridge University Press.

"Study of Man's Impact on Climate" (1971) in *Inadvertent Climate Modification*, Cambridge, MA: M.I.T. Press, pp. 166-167.

Terjung, W. H. (1974) "Climatic Modification," in I. R. Manners and M. W. Mikesell (eds.), *Perspectives on Environment*, Washington, D.C.: Association of American Geographers, pp. 105-151.

Tiebout, Charles M. (1956) "The Pure Theory of Local Government Expenditures," *Journal of Political Economy*, October, pp. 416-424.

United Nations (1974) *Projections of Urban Population*, New York: U.N. Population Division, September. Mimeographed.

United States Environmental Protection Agency (1972) *Air Quality Data—1972 Annual Statistics*, Washington, D.C.: U.S. Government Printing Office.

——— (1973) *Land Use and the Environment: An Anthology of Readings*. Washington, D.C.: U.S. Government Printing Office.

——— (1974a) *The 1972 National Emissions Report (NEDS)*. Washington, D.C.: U.S. Government Printing Office.

——— (1974b) *Development of a Trial Air Quality Maintenance Plan*, Washington, D.C.: U.S. Government Printing Office, EPA-450/3-74-050, September.

——— (1975) *The Cost of Clean Air*. Washington, D.C.: U.S. Government Printing Office.

Watson, Peter and Edward Holland (forthcoming) "Innovative Strategies in Urban Transportation, The Case of Singapore," in T. R. Lakshmanan and L. Chatterjee (eds.), *Urbanization, Labor Absorption and Environmental Quality in Latin America*.

White, Morton and Lucia White (1962) *The Intellectual Versus the City*, Cambridge, MA: Harvard University Press.

Wingo, Lowden (1973) "The Quality of Life: Toward a Microeconomic Definition," *Urban Studies*, Vol. IV, pp. 3-18.

Wolman, Abel (1956) "Disposal of Man's Wastes," in W. L. Thomas (ed.), *Man's Role in Changing the Face of the Earth*, Chicago: University of Chicago Press, pp. 807-816.

Wolman, M. Gordon (1973) "The Physical Environment and Urban Planning," in *Geographic Perspectives and Urban Problems*, Washington, D.C.: National Academy of Sciences, pp. 55-70.

Wolman, M. Gordon and A. P. Schick (1967) "Effects of Construction on Fluvial Sediment, Urban and Suburban Areas of Maryland," *Water Resources Research*, Vol. 3, pp. 451-464.

World Bank (1972) *Urbanization, Sector Working Paper*, Washington, D.C., June.

——— (1975) *Housing, Sector Policy Paper*, Washington, D.C.

World Health Organization (1973) *Special Subject: Community Water Supply and Sewage Disposal in Developing Countries*, World Health Statistics Report, Vol. 26, No. 11.

Zahavi, Y. (1976) *Travel Characteristics in Cities of Developing and Developed Countries*, Washington, D.C.: World Bank Staff Working Paper No. 230, March.

Zobler, L., G. W. Carey, M. R. Greenberg, and R. M. Hordon (1976) "A Geographical Systems Analysis of the Water Disposal Networks of the New York Metropolitan Region," *Geographical Review*, Vol. 66, No. 1, pp. 32–47.

ASSOCIATION OF AMERICAN GEOGRAPHERS

Commission on College Geography Publications

Resource Papers*

1. *Theories of Urban Location*, B. J. L. Berry, 1968
2. *Air Pollution*, R. A. Bryson, J. E. Kutzbach, 1968
3. *Perspectives on Geomorphic Processes*, G. H. Dury, 1969
4. *Spatial Diffusion*, P. R. Gould, 1969
5. *Perception of Environment*, T. F. Saarinen, 1969

*6. *Social Processes in the City: Race and Urban Residential Choice*, H. M. Rose, 1969

*7. *The Spatial Expression of Urban Growth*, H. M. Mayer, 1969 (to be revised, 1978)

8. *The Political Organization of Space*, E. W. Soja, 1971
9. *An Introduction to Spatial Allocation Analysis*, A. J. Scott, 1971
10. *Man and Nature*, Yi-Fu Tuan, 1971
11. *Tropospheric Waves, Jet Streams, and United States Weather Patterns*, J. R. Harman, 1971
12. *The Spatial Structure of Administrative Systems*, B. H. Massam, 1972
13. *Residential Mobility in the City*, E. G. Moore, 1972
14. *The Periglacial Environment, Permafrost, and Man*, L. W. Price, 1972
15. *Conservation, Equilibrium, and Feedback Applied to Atmospheric and Fluvial Processes*, J. N. Rayner, 1972
16. *Metropolitan Neighborhoods: Participation and Conflict Over Change*, J. Wolpert, A. Mumphrey, J. Seley, 1972
17. *Computer Cartography*, T. K. Peucker, 1972
18. *Society, The City, and The Space-Economy of Urbanism*, D. Harvey, 1972
19. *Thematic Cartography*, P. Muehrcke, 1972
20. *Man and Environment*, K. Hewitt, F. K. Hare, 1972
21. *The Use , Radar Imagery in Climatological Research*, A. Williams, Jr., 1973
22. *Misused and Misplaced Hospitals and Doctors*, P. deVise, 1973
23. *Visual Blight in America*, P. Lewis, Yi-Fu Tuan, D. Lowenthal, 1973
24. *Values in Geography*, Sister Annette Buttimer, 1974
25. *Participation, Decentralization, and Advocacy Planning*, R. E. Kasperson, M. Breitbart, 1974
26. *Interurban Systems and Regional Economic Development*, W. B. Stöhr, 1974
27. *Major Job-Providing Organizations and Systems of Cities*, A. R. Pred, 1974
28. *The Underdevelopment and Modernization of the Third World*, A. R. de Souza, P. W. Porter, 1974

General Series*

10. *Geography in the Two-Year Colleges*, Panel on Geography in the Two-Year Colleges, 1970
12. *Planning College Geography Facilities*, R. H. Stoddard, 1973
13. *Perspectives on Environment*, Panel on Environmental Education; I. R. Manners and M. W. Mikesell, editors, 1974

Resource Papers for College Geography

1975 Series

RP 75-1. *Land Use Control: Interface of Law and Geography*, R. H. Platt

RP 75-2. *The Outer City: Geographical Consequences of the Urbanization of the Suburbs*, P. O. Muller

RP 75-3. *Triumph or Triage? The World Food Problem in Geographical Perspective*, C. G. Knight, P. Wilcox

RP 75-4. *Maps, Distortion, and Meaning*, M. S. Monmonier

1976 Series

RP 76-1. *The Geography of International Tourism*, I. M. Matley

RP 76-2. *Social Aspects of Interaction and Transportation*, F. P. Stutz

RP 76-3. *Landscape in Literature*, C. L. Salter, W. J. Lloyd

RP 76-4. *Geography and Mental Health*, C. J. Smith

1977 Series

RP 77-1. *Urbanization and Environmental Quality*, T. R. Lakshmanan, L. R. Chatterjee

RP 77-2. *Changing Migration Patterns Within the United States*, C. C. Roseman

RP 77-3. *Spatial Perspectives on School Desegregation and Busing*, J. D. Lord

RP 77-4. *Energy: The Ultimate Resource?*, E. Cook

For information on these publications, write to: Association of American Geographers, 1710 Sixteenth Street, N W., Washington, D.C. 20009.

* Out-of-print Commission on College Geography Publications are available in hard cover and in microfiche from ERIC/ChESS, 855 Broadway, Boulder, CO 80302.